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Corrosion-Resistant Materials for Water and Wastewater Treatment Plants at Fort Bragg

Final Report on Project AR-F-319 for FY05

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Final report

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Abstract: Corrosion prevention and control technologies using advanced materials and coatings were implemented at the water treatment and wastewater treatment facilities at Fort Bragg, NC. This project demonstrated that:

1. Microsilica cement mortar and epoxy based coatings, approved for potable water according to National Sanitation Foundation (NSF) Standard 61. were applied to the potable water treatment filter tanks. These coatings form a high strength moisture barrier with a strong chemical/mechanical bond to brick and cementitious substrates.
2. Coal-tar epoxy coatings are efficacious in the presence of moderate concentrations of airborne chlorine and hydrogen sulfide gases and were used in wastewater treatment facilities.
3. Fiber- reinforced plastic (FRP) doors, which provide excellent mechanical durability and superior resistance to sunlight and corrosion, especially in chlorine storage facilities, were installed.

These technologies are applicable to other potable water treatment plants and wastewater treatment plants for Army and DoD installations, and can be expected to result in restoration of the plants to optimum operating conditions and significant cost avoidance due to increased service life.

Contents

Introduction

The U.S. Army Engineer Research and Development Center (ERDC) contracted with S & K Technologies, St. Ignatius, MT (subcontractor Allied Corrosion Industries, Inc. (ACI) of Marietta, GA) under OSD FY05 Project No. AR-F-319 to conduct field demonstration and implementation of several emerging corrosion prevention and control technologies at both the Water Treatment Plant (WTP) and their Wastewater Treatment Plant (WWTP) owned and operated by Fort Bragg, NC, Directorate of Public Works (DPW). Allied Corrosion retained Steele and Associates to complete the concrete restoration and coatings. Allied Corrosion performed the door replacements and repairs to ten electrical panel boxes. Corrosion Control Incorporated was retained by ERDC-CERL as a subcontractor to S & K Technologies, to assure the quality of the contractors work, document the achieved reduction in corrosion/degradation, and assist in evaluating the Return on Investment for the project.

The Project Manager was Dr. Ashok Kumar. The Associate Project Manager was Dr. L. D. Stephenson. The stakeholders are Judi Hudson (Deputy DPW) and Brenda Audette (Supervisor of the Fort Bragg WTP and WWTP), George Whitley (Fort Bragg DPW Office), Steve Jackson (Installation Management Agency – South East Region Office), Paul Volkman (Headquarters-Installation Management Command), David Purcell, (Headquarters, Assistant Chief of Staff for Installation Management), and Hilton Mills (Army Materiel Command), as well as Tri-Services Working Integration Process Team representatives, Nancy Coleal (Air Force Civil Engineering Service Agency, and Tom Tehada (Naval Facilities Engineering Systems Command).

At the time this report was prepared, the Acting Chief of the ERDC-CERL Materials and Structures Branch was Vicki L. Van Blaricum, the Chief of the Facilities Division was L. Michael Golish, and the Technical Director for Installations was Martin J. Savoie. The Deputy Director of ERDC-CERL was Dr. Kirankumar V. Topudurti, and the Director was Dr. Ilker Adiguzel.

COL Gary E. Johnston was the Commander and Executive Director of ERDC, and Dr. James R. Houston was the Director.

Executive Summary

Corrosion prevention and control (CPC) technologies using advanced corrosion resistant materials and coatings were demonstrated and implemented at Fort Bragg, NC. A total of seven tasks were completed at the water treatment facility and five tasks were completed at the wastewater treatment facility as follows:

A. Water Treatment Plant

1. Refurbish the concrete surfaces within six single cell water filters.
2. Refurbish the concrete surfaces within four dual cell water filters.
3. Refurbish the coating on the metal troughs and wash piping on the six single filter cells.
4. Coat the newly installed wash piping in the seven dual filter cells.
5. Refurbish the coating system on 19 underground valve pits.
6. Refurbish the coating system on one large above ground manifold.
7. Refurbish the coating system on two electrical panel boxes for the recirculation pumps.

B. Wastewater Treatment Plant

1. Refurbish the coating system on 17 outside light poles.
2. Refurbish the coating system of 19 hand wheels and refurbish the coating system on 11 hand wheel operator stands.
3. Recondition ten stainless steel electrical panel boxes.
4. Replace two double doors and one single door with FRP doors on the chlorine storage building.
5. Replace three badly corroded operating valve hand wheels that were unsalvageable.

This project has demonstrated that:

1. Microsilica cement mortar and epoxy based coatings, approved for potable water according to National Sanitation Foundation (NSF) Standard 61, when applied to the filter tanks, forms a high strength moisture barrier with extremely low permeability and a strong chemical/mechanical bond to brick and cementitious substrates.

2. Coal-tar epoxy coatings are efficacious in the presence of moderate concentrations of airborne chlorine and hydrogen sulfide gases that are routinely found in wastewater treatment facilities.

3. Fiber- reinforced plastic (FRP) doors made of phenolic honeycomb core construction that provide excellent mechanical durability and superior resistance to sunlight and corrosion were installed. These technologies are applicable to other water treatment plants and wastewater treatment plants at Army and Department of Defense (DoD) installations, and can be expected to result in restoration of the plants to optimum operating conditions at significant cost avoidance, by extending the service life of components. It is recommended that existing relevant Unified Facilities Guide Specifications (UFGS) be modified to include the industry and government specifications and instructions for implementing the corrosion prevention and control materials selection and coatings technologies demonstrated under this project.

Unit Conversion Factors

Multiply	By	To Obtain
inches	0.0254	meters
mils	0.0254	millimeters

1 Background

The installation of Fort Bragg includes a potable WTP and a WWTP, operated by DPW. Both of the plants are actually located just outside Pope Air Force Base, on Manchester Road in Spring Lake, NC. The treatment vessels, pipelines, pumps and buildings within each plant have been in service for more than 20 years. Over this time, the structures have been subject to varying levels of degradation. Most of the structural degradation was due to corrosion of metals and chemical attack of concrete. To extend the service life of the water plants, this project was implemented to restore structural coatings and concrete surfaces. The project was funded by the Office of the Secretary of Defense (OSD) CPC Program FY05 Project entitled "AR-F-319 – Corrosion-Resistant Materials for Water and Wastewater Plants."

ERDC-CERL, in close coordination with the personnel at Fort Bragg, recognized that many of the structures at Fort Bragg's WTP and WWTP were experiencing corrosion attack. The corrosion attack was primarily due to the breakdown of coating systems over years of exposure to high humidity, combined with airborne chemicals used at both facilities.

Under the first task of this project, ERDC-CERL retained Allied Corrosion, as a subcontractor to S&K Technologies, to implement corrosion reduction measures within the water plants at Fort Bragg. The structures identified for repair were:

A. Water Treatment Plant

1. Six single cell filter tanks.
2. Seven dual cell filter tanks.
3. Wash piping and troughs associated with six single filter tanks.
4. Wash piping associated with four dual filter tanks.
5. Piping and valves within nineteen underground valve pits.
6. One large above ground out door piping manifold.
7. Two electrical panel boxes for the recirculation pumps.

B. Wastewater Treatment Plant

1. Seventeen metal light poles.
2. Nineteen valve stands and wheel handles.
3. Ten electrical panel boxes.
4. Three doors on the chlorine building.
5. Three valve handwheel

Allied Corrosion began work on the rehabilitation of the water plant structures in June 2005. Allied Corrosion retained Steele and Associates to complete the concrete restoration and coatings. Allied Corrosion performed the door replacements and repairs to ten electrical panel boxes. Corrosion Control, Inc. was the Quality Control Inspector for this project.

2 Lessons Learned

If these technology solutions had not been implemented, components of the potable water treatment plant and the wastewater treatment plant would continue to deteriorate, and the plants would be forced to shut down more frequently for repairs. The WTP at Fort Bragg provides mission-critical water for both Fort Bragg and the adjacent Pope Air Force Base for fire fighting, including fire suppression systems in buildings, fire hydrants, and aircraft deluge systems. During WTP shutdown periods, the lack of water could result in catastrophic loss of fire suppression capability, thereby endangering lives and property, and delaying aircraft flights. Aircraft flight training is cancelled if fire suppression systems are leaking. Also, military deployment missions can be compromised due to lack of water for aircraft fire suppression systems and due to lack of water to fill potable water tanks that are shipped with troops being deployed to arid regions. Corrosion problems at the wastewater treatment plant may lead to eventual inability of the plant to operate properly, resulting in the discharge of improperly treated waste, which is a costly environmental violation. The use of advanced corrosion-resistant materials and guidance on materials selection would provide the benefits of restoring the WTP and the WWTP to optimum operating condition, as well as reducing maintenance, and increasing safety. This project has the potential for far-reaching impact across the DoD.

The technologies demonstrated and implemented under this project are recommended for all Army and DoD that own and operate potable WTP and WWTP. It is recommended that revisions to existing UFGS include the specifications and instructions for implementing the corrosion prevention and control materials selection and coatings technologies demonstrated under this project. The applicable UFGS that are candidates for revisions are the materials selection sections in the following UFGS:

- UFGS 0997040 C-200 Coal Tar Epoxy Polyamide Paint
- UFGS 08120 Aluminum Doors and Frames
- UFGS 08165A Sliding Metal Doors

- UFGS 08710 Door Hardware
- UFGS 02510A Water Distribution System
- UFGS 16528A Exterior Lighting Including Security and CCTV Applications

3 Technical Investigation

Problem statement

Fort Bragg has identified severe corrosion problems at both the WTP and the WWTP due to the harsh environments of chlorine and sewer gases, respectively. In addition, both facilities are subject to an atmospherically corrosive environment with a combination of heat and high humidity. Deteriorating components include metallic equipment, metallic structures, and concrete structures. Both the WTP and WWTP were constructed during 1940-1950, and many components are nearing the end of their design lives (U.S. Army Corps of Engineers, "Should-Cost Model for Privatization of Water-Wastewater Utility System"). WTP and WWTP at about 20 other Army installations also face these corrosion problems. In addition, similar corrosion problems are present at water and wastewater treatment plants at other installations in the Tri-Services.

Objectives

The objectives of this project were to:

1. Restore the WTP and WWTP to optimum operating conditions using advanced materials selections.
2. Demonstrate proper selection and implementation of corrosion-resistant materials to replace low alloy steel components.
3. Select and implement corrosion-resistant coatings for light posts, valve hand wheels, pipes, and restoration coatings for concrete flocculation tanks and filter tanks.
4. Develop Industry or Government Specifications and Standards for other DoD installations.

Judicious selection of emerging corrosion-resistant coatings and alternative corrosion-resistant materials, and implementation of cathodic protection for tank and machinery components, can provide the needed corrosion protection.

Technology solutions

The following advanced materials selections and coatings were implemented at Fort Bragg for the potable WTP and the WWTP (as indicated below):

1. Refurbish the concrete wall coating in the single filters at the WTP.
2. Refurbish the concrete in dual filters (2 cells/filter) at the WTP.
3. Refurbish the coating in the single filters on the metal troughs and wash piping at the WTP.
4. Coat the new wash piping in the dual filters at the WTP.
5. Refurbish the coating on the piping and valves in below ground pits at the WTP.
6. Refurbish the coating on large, above ground piping manifold at the WTP.
7. Refurbish the coating on electrical panel box at the WTP
8. Refurbish the coating on 40-ft tall yard light poles at the WWTP.
9. Refurbish the coating on remote valve hand wheels and valve stem operator stands at the WWTP.
10. Refurbish and seal stainless steel electrical motor control/circuit breaker panel boxes at the WWTP.
11. Replace one single and two double metal doors with FRP doors at the WWTP.
12. Replace remote valve hand wheels and remote operator stands at the WWTP.

Additional information is provided in Appendix 1.

Results

Water treatment plant

1. *Refurbish the concrete wall coating in the single filters*. These tasks involved the rehabilitation of the concrete walls in single cell filters No. 1 through 10. All deteriorated concrete and coatings were removed, and the walls were cleaned down to the sound coated concrete surfaces. Mainstay ML-72 Microsilica Restoration Mortar was then applied over those exposed concrete surfaces and troweled smooth (at +/- ½-in. thickness) to restore the concrete walls to their original thickness. The ML-72 mortar was then coated with 20 to 25 mils of Madewell 1103 Epoxy Coal Tar coating and top-coated with 16 mils of Mainstay DS-4 epoxy. Mainstay ML-72 Sprayable Microsilica Cement Mortar is a restoration mortar that forms a

high strength moisture barrier with extremely low permeability and a strong chemical/mechanical bond to brick and cementitious substrates, and can be applied by low to medium velocity wet mix shotcrete equipment (pneumatic spray) or by using a hand trowel. It is a blend of special cements, microsilica, thermoplastic fiber, densifiers, polymer admixtures and other modifiers that produces a high strength, low shrinkage, and low permeability mortar for rehabilitation of deteriorated concrete structures. Mainstay ML-72 produces excellent adhesion to properly prepared existing concrete or brick surfaces. Mainstay ML-72 restores structural integrity, seals rough deteriorated surfaces, resists external hydrostatic water pressure, and is suitable for permanent water immersion service.

Mainstay DS-4 is a 100% solids, chemically modified epoxy coal tar coating utilizing a unique, multi-component curing system that contributes to a number of superior properties: toughness, permanent flexibility, and improved chemical and temperature resistance. This sprayable system may be applied at thicknesses up to 100 mils or more in a single application, thereby reducing application costs. The absence of solvent reduces shrinkage, cracking and disbonding and eliminates the problems related to solvent entrapment. Mainstay DS-4 cures relatively fast at 40 °F and under high moisture conditions - even under water. This property enables field applications under a variety of weather conditions, resulting in minimum downtime. Mainstay DS-4 exhibits superior ultraviolet and sunlight resistance after years of exposure. Mainstay DS-4 is particularly well suited for use as a topcoat over Mainstay ML-72 Microsilica Cement mortar. These coatings are approved for potable water service according to NSF Standard 61 (see also Appendix 3). Before and after photographs are shown as Figure 1a and 1b in the water photographic journal section (Appendix 2). Additional specifications may be found on the Product Data Sheets (PDS) for these materials, as given in Appendix 3.

2. *Refurbish the concrete in dual filters (two cells/filter).* This task involved the rehabilitation of the concrete walls in dual filters No. 7, 8, 9, 10, 11, 12, and 13. The same procedure was followed for these filters as was done with the single cell concrete filters. Before and after photographs are shown as Figure 2a and Figure 2b, respectively in the water photographic journal section (Appendix 2). The PDS for these materials are included in Appendix 3.

3. *Refurbish the coating in the single filters on the metal troughs and wash piping*. This task involved the rehabilitation of the metal troughs and surface wash piping in single cell water filters No. 1 through 6. The steel troughs and piping were abrasively blasted to SSPC-10 (near white metal). The prepared surfaces of the troughs were then coated with 20 mils of Madewell 1103 coal tar epoxy and 16 mils of Mainstay DS-4 epoxy. The wash piping was coated with 16 mils of Mainstay DS-4 epoxy, approved for potable water service according to NSF Standard 61. Madewell 1103, a 100% solids, chemically modified epoxy coal tar coating, represents a major breakthrough in the performance of epoxy coal tar systems. Its unique, multi-component curing system contributes to a number of superior properties: toughness, permanent flexibility, and improved chemical and temperature resistance. This sprayable system may be applied in thickness up to 40 mils or more in a single application, which reduces application costs. The absence of solvent reduces shrinkage, cracking and disbonding and eliminates the problems related to solvent entrapment. The system remains quite flexible when mixed with select siliceous fillers (up to 100% by weight). Madewell 1103 cures relatively fast at 40 °F and under high moisture conditions, even under water. This property enables field applications under a variety of weather conditions resulting in minimum downtime. Madewell 1103 exhibits superior ultraviolet and sunlight resistance after years of exposure. Common chalking, checking, and embrittlement problems associated with traditional epoxy coal tar systems are not present with this system. Madewell 1103 meets the requirements of:

- The U.S. Environmental Protection Agency's extractables protocol for coatings to be used in potable water service.
- The American Society for Testing and Materials (ASTM) Specification C-541.
- Performance criteria for the American Water Works Association Specification C-210.

Before and after photographs are shown as Figure 3a and Figure 3b, respectively in the water treatment plant photographic journal section (Appendix 2). Additional specification information may be found on the PDS for these materials, as given in Appendix 3. Certain unforeseen field conditions ultimately led to premature corrosion in some areas (estimated to be less than 1% of the total trough surface area). The problem areas were all concentrated in tight, difficult to access spots, such as segments of angle iron mounted back-to-back, bearing plates attached directly to (and in in-

timate contact with) the angle iron, bolted connections through both the angle iron and bearing plates and overlapping joints in each of the segmented steel trough sections. The steel troughs (SCF No. 1-3) were abrasive blasted to Society of Protective Coatings (SSPC)-SP 10 (near white metal) and the concrete troughs (SCF No. 4-6) were prepared using low-pressure water blasting (SSPC-SP 12) in conjunction with power tool cleaning (SSPC-SP 3). The vast majority of the area involved (i.e., those areas that do not show signs of premature corrosion) will perform as intended for many years to come. With respect to the "problem areas" described above, spot repair of each of the affected areas have been made, first by power tool cleaning in accordance with SSPC-SP3, followed by a hand application of Madewell 1312P Thixotropic Epoxy Putty to fill/seal off the "crevices" before finally hand-applying additional Madewell DS-4 to achieve the desired final topcoat dry film thickness. Additional specifications may be found on the PDS for these materials, as given in Appendix 3.

Madewell® 1312P is a 100% solids thixotropic epoxy putty for use in filling irregular surfaces such as voids and bugholes in concrete prior to the application of protective or reinforcing topcoats. This two component product can be applied by trowel or squeegee. The absence of solvents reduces shrinkage, cracking, and disbonding and eliminates problems related to solvent entrapment. Additional specifications may be found on the PDS for these materials, as given in Appendix 3.

4. *Coat the new wash piping in the dual filters*. This task involved the rehabilitation of the metal troughs and surface wash piping in single cell water filters No. 7 through 13 The same procedure was followed as for the single filters on the metal troughs and wash piping in item 3, above. Before and after photographs are shown as Figure 4a and Figure 4b, respectively in the water treatment plant photographic journal section (Appendix 2).

5. *Refurbish the coating on the piping and valves in below ground pits*. This task involved repairing the coatings on the water pipes and associated valves within 19 underground valve pits in the fresh water plant. The pipes, valves, and fittings were sandblasted to near white metal (SP-10). The contractor then applied 20 to 25 mils of 1103 coal tar epoxy. Figure 5 is a photograph of one of the newly coated valve pits (Appendix 2).

6. *Refurbish the coating on large, above ground piping manifold*. This task involved the repair of coatings on the 20-in. φ manifold piping behind the filter building in the fresh water plant. The piping was abrasively blasted to near white metal (SSPC-SP 10), and then 20 to 25 mils of Madewell 1103 epoxy were applied. Figure 6 is a photograph of the newly coated piping manifold (Appendix 2).

7. *Refurbish the coating on electrical panel box*. This task involved the repair of two electrical panel boxes in the water plant that service recirculation pumps No. 1 and 2. The boxes were abrasively blasted to near white metal (SSPC-SP 10). Then 10 mils of Madewell 1312S epoxy were applied and top coated with 2 to 3 mils of Madewell 1450 urethane. Madewell® 1312S is a heavy duty, 100% solids two component epoxy coating product. It is used for both new construction and maintenance of steel and concrete surfaces in tanks, sumps, trenches, decks, and pipe interiors and other process equipment and structures in chemical processing, power, refining, mining, pulp/pape,r and oil refining industries. Madewell 1312S may be used as a topcoat for other Madewell 1312 series coating systems to add color and/or seal the surface.

Madewell 1312S protects surfaces against chemical attack under immersion, spill, and splash conditions and impact and abrasion damage by rough use or heavy traffic. It is normally applied at a nominal thickness of 10 to 25 mils in two coats. Being attractive and easy to clean, its monolithic construction resists moisture, chemical, and bacterial penetration. Its free spreading characteristics, fast set time, and easy cleanup help to minimize labor costs and down time. Additional specifications may be found on the PDS for these materials, as given in Appendix 3. Figure 7 presents a view of a typical electrical panel box after refurbishment in the photographic journal section (Appendix 2).

Wastewater treatment plant

1. *Refurbish the coating on 40-ft tall yard light poles*. This task involved repairs to 17 light posts within the wastewater treatment plant. The contractor wet blasted the square metal posts, including the base plates, to white metal (SSPC-SP 10). A 20 to 25 mil coat of 1103 coal tar epoxy was applied, followed by 2-3 mils of urethane 1450. Before and after photographs are shown as Figures 8a and 8b, respectively, in the wastewater photographic journal section (Appendix 2). Additional specifications may be found on the PDS for these materials, as given in Appendix 3.

2. *Refurbish the coating on remote valve hand wheels and valve stem operator stands*. This task involved the repair of valve stands and valve wheels within the WWTP, sand blasting and coating 19 valve wheels, and sand blasting and coating 11 valve stem operator stands. The wheels and stands were sand blasted to SSPC-SP 10. Once cleaned, the wheels and stands were coated with at least 20 mils of Madewell 1103 coal tar epoxy and 2 to 3 mils of Madewell 1450 urethane. Before and after photographs are shown as Figures 9a and 9b, respectively, in the wastewater photographic journal section (Appendix 2). PDS for these materials are given in Appendix 3.

3. *Refurbish and seal stainless steel electrical motor control/circuit breaker panel boxes*. This task involved repairs to ten existing electrical disconnect boxes on various pump and mixer motors in the wastewater plant. The boxes are primarily stainless steel, with a mixture of galvanized, polyvinyl chloride (PVC) and PVC-coated flexible conduits. The contractor inspected each box, replaced damaged hinges and hasps, repaired conduit connections, replaced missing or damaged gaskets with corrosion-resistant nitrile gaskets, and sealed the conduits. Before and after photographs are shown as Figure 10a and Figure 10b, respectively, in the wastewater photographic journal section (Appendix 2). Nitrile or buna-N rubber seals are used more than all the other elastomers combined, since nitrile is the most versatile material and is not as likely to fail as do most other rubber gaskets and seals due to the natural breakdown of the elastomeric molecular bond of rubber when stressed (e.g., compressed, elongated). Additional specifications may be found on the PDS for these materials, as given in Appendix 3.

4. *Replace one single and two double metal doors with FRP doors*. This task involved replacement of five sets of doors on the chlorine injection building (V-3408), within the potable water plant. The original steel doors and frames were removed, and the thresholds cleaned. New fiberglass frames and doors were then installed with stainless steel hardware. The new doors (manufactured by Tiger Doors) were of phenolic honeycomb core construction with exclusive press molding technology, yielding an integrally fused product. They also have a polyurethane skin coating on that provides the same excellent mechanical durability and superior resistance to sunlight, moisture, and chemicals. They carry a lifetime warranty as it specifically relates to delamination or corrosion, excluding third-party damage, vandalism, force majeure events, etc. Before and after photo-

graphs are shown as Figures 11a and 11b, respectively, in the wastewater photographic journal section in Appendix 2. Appendix 3 provides additional specification on the FRP doors. Appendix 4 presents a more detailed report on FRP doors installed at Fort Bragg under this OSD-sponsored project and at Fort Drum, NY, under a previous corrosion control technology demonstration project.

5. *Replace remote valve hand wheels and remote operator stands*. Three hand wheels were unsalvageable and had to be replaced. They were replaced with a corrosion-resistant aluminum alloy B26-525. Before and after photographs are shown as Figures 12a and 12b, respectively, in the wastewater photographic journal section in Appendix 2.

Specifications used at Fort Bragg

Project 1: Refurbish the concrete surfaces in single or dual cell water filters in water treatment plants.

In WTPs, the concrete surfaces of the single and dual water filters deteriorate over time. This deterioration occurs primarily due to chlorine attack on the concrete mortar. This is evidenced by exposed aggregate in the surface of the concrete.

Chloride attack of the concrete's reinforcement steel is also a problem. This is evidenced by cracks forming in the concrete walls with reddish brown stains forming on the concrete surface. The reddish brown stains are nothing more than iron oxide (rust). When steel corrodes, it expands approximately seven times its original volume. Consequently, when steel reinforcement bar (rebar) corrodes, something has to give and it is always the concrete. The extreme high forces developed by the corroding rebar are too great for the concrete, which cracks.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Use Madewell's Mainstay Composite Liner Rehabilitation and Corrosion Protection System or equivalent (See PDS in Appendix 3). This process begins by low-pressure water blasting (SSPC-SP12) in conjunction with power tool cleaning (SSPC-SP3) the concrete surfaces and removing all loose concrete down to sound concrete, and removing all contaminants.

2. If cracks in the concrete are exposed due to corroding rebar, then follow the repair procedures found in the book titled *Concrete Repair and Maintenance Illustrated* by Peter H. Emmons and published by RS Means-CMD Group.
3. After cracks are repaired, Mainstay ML-72 sprayable micro-silica restoration mortar or equivalent (See PDS in Appendix 3). is then applied to the saturated concrete substrates to an average thickness of ½ in. After the mortar has achieved its initial set (usually in 1 to 3 hours), Madewell 1103 Epoxy Coal Tar Coating or equivalent (See PDS in Appendix 3) is spray-applied to the mortar to an average thickness of 25 mils (~ 1/32 in.).
4. After overnight cure, these tanks will be top-coated with Mainstay DS-4 Epoxy Coating or equivalent (See PDS in Appendix 3). to minimum thickness of 16 mils in two coats. This coating is approved for potable water service according to NSF Standard 61.
5. After 24 hours of cure at 73 °F, the filter tank can be put into service.

Project 2: Recoat the metal troughs and/or wash piping in water treatment plant's filters.

In most of the sand filters in use in WTPs today, some incorporate steel troughs, including spraying arms and related piping. These items, along with their associated steel support members, are highly susceptible to galvanic corrosion reaction. The first step in protecting this asset is the installation of a high quality coating, followed by the installation of a cathodic protection system. Both are needed to comprehensively protect this asset.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Sandblast all metal components to SSPC-SP 10.
2. Next, coat the metal troughs and surface wash metal piping with two coats of Mainstay DS-4 Epoxy Coating or equivalent (See PDS in Appendix 3) to an average thickness of 16 mils. The coating is approved for potable water service according to NSF Standard 61.
3. After 24 hours of cure at 73 ˚F, the filter tank can be put into service.

Project 3: Recoat the piping and valves located in valve pits, including any above-ground piping manifolds found in WTPs.

Whenever large diameter metal piping/valves are exposed to the outside environment, most typical paints cannot protect those assets from atmos-

pheric corrosion. Some of these items are located in valve pits, where water can collect, making the corrosion issue much worst. To mitigate this problem, a coating system design specifically for this purpose needs to be used.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Sandblast all metal components to SSPC-SP 10.
2. Next, coat the large-diameter metal piping/valves with two coats of Madewell 1103 Epoxy Coal Tar coating or equivalent (See PDS in Appendix 3) to an average thickness of 25 mils.

Project 4: Refurbish the coating system on existing electrical panel boxes

Very frequently, standard steel electrical panel boxes have to be mounted outside in the elements. After several years in these harsh environment conditions, such as those found at WWTPs, the electrical panel box's paint system breaks down. The resulting corrosion can be very costly. Not only does it cost to replace the box, but the downtime of the equipment associated with the replacement and/or the repair is also costly.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Sandblast the exterior of the electrical panel box to near-white metal condition (SSPC-SP 10/ NACE 2).
2. Next, coat all sandblasted areas with one coat of Madewell 1312S White Epoxy Coating or equivalent (See PDS in Appendix 3) to a dry film thickness of 10 mils.
3. Upon curing to a tack free condition, apply one coat of Madewell 1450 (White) Urethane Coating or equivalent (See PDS in Appendix 3) to a dry film thickness of two mils.

Project 5: Refurbish the coating system yard light poles

Whenever outside yard lighting is located at water treatment facilities, the metal poles supporting the lights are subjected to very harsh environments of moisture and hydrogen sulfide. These two compounds attack the support pole's coating system. The result is accelerated corrosion of the metal

substrate. If not properly coated with a coating system designed to survive in that environment, the asset is doomed to be lost prematurely.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Sandblast the light pole to SSPC-SP 10.
2. Coat the pole with Madewell 1103 Epoxy Coal Tar Coating or equivalent (See Product Data Sheets in Appendix 3) to minimum thickness of 25 mils, followed by one coat of Madewell 1450-Dark Bronze or equivalent (see PDS in Appendix 3) to a dry film thickness of 2.0 mils.

Project 6: Refurbish the coating system on wastewater hand wheel support stands

In most wastewater treatment facilities, valves are located either directly in or near the sewage stream as it enters the facility. These types of installations require valve operation from a remote location, which is generally some number of feet directly above the actual valve. The typical method of handling this situation is to fabricate a metal stand and mount a remote hand wheel to the stand. With an installation of this kind, the valve can be opened or closed remotely; thus providing the plant technician some measure of safety. The metal components of these installations are subject to high concentrations of moisture, hydrogen sulfide, and acids. These conditions provide the key elements for accelerated corrosion and, unless the coating system is specifically designed for this environment, the coating will not last long and the asset is sacrificed.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Sandblast the remote valve operator support stands to SSPC-SP 10.
2. Coat the support stands with Madewell 1103 Epoxy Coal Tar Coating or equivalent (see PDS in Appendix 3) to a minimum thickness of 25 mils, followed by one coat of Madewell 1450-Silver or equivalent (see PDS in Appendix 3) to a dry film thickness of 2.0 mils

Project 7: Refurbish the coating system on WWTP's remote valve operator-hand wheels.

Please refer to the comments and specification for the previous project. Project 7 is directly related and is part of the previous project. Consequently, the comments will not be repeated here.

Project 8: Recondition and protect existing stainless steel electrical panel boxes from wastewater atmospheric corrosion issues.

To combat the issue of corrosion, most wastewater treatment facilities will install stainless steel electrical panel boxes. When they are located in the harsh environment associated with the head works and primary clarifiers of a wastewater treatment facility, the non-stainless steel components of the boxes are quickly corroded. In a majority of cases, the metal latches of stainless steel boxes are steel and are affixed to the box via aluminum pop rivets. When these components are used, it does not take long for them to corrode away, allowing the corrosive atmosphere to attack the electrical components inside the box.

Another consideration for protecting the internal electrical components of an electrical box is to seal the conduit penetrations into the box. Sealing is not limited to only the hole cut into the box where the conduit enters, but also includes isolating the transfer of atmosphere that can travel inside the conduit itself. Both of these areas of concern are a potential source where corrosive atmospheres may enter the electrical panel box and cause severe corrosion damage. When these conditions exist, specific preventative maintenance steps can be taken to protect these assets.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Where necessary, install new stainless steel latches with stainless steel hardware (pop-rivets).
2. Where practical, install PVC fittings at the conduit enclosure entry points. Seal all penetrations with a high quality, UV-resistant, chemical-resistant metal sealant.
3. Where practical, install Chico A-05 compound or equivalent (see PDS in Appendix 3) in all conduit openings. Some conduit penetrations do not lend themselves to the installation of this compound. The reason for this is, this compound is a viscous liquid and cannot be held in place while cur-

ing in an upside down, vertical penetration. In these cases, use "Polyurethane Insulating Foam Sealant."
4. Install new chemical resistant door gaskets made specifically for electrical panel boxes (Nitrile Degradation – Resistant Seals).
5. Coat all metal conduit items that penetrate the electrical panel box with liquid PVC coating.

Project 9: Replace corroding wastewater building metal doors with FRP doors.

Almost all of the buildings in WTPs and WWTPs have steel metal doors. They have served the industry quite well over the years. However, when these doors are in buildings that store highly corrosive chemicals such as chlorine, they offer little resistance to corrosion. In these cases, one solution is to install a high quality FRP door with either B26-535 aluminum alloy or 304 stainless steel hardware (see Appendix 4). For this project, the manufacturer was Tiger Doors Inc., which was judged the best on the market.

The following were included in the specifications for the Fort Bragg WTP and WWTP:

1. Specify Tiger FRP doors or equivalent (see PDS in Appendix 3). The FRP door representative is to take all door measurements from the existing building to ensure that each door fits properly. All doors are custom made. Consequently, nothing is worse than to measure a door incorrectly and have to return it because of incorrect measurements. This point is very crucial to a successful installation.
2. The FRP door representative is to install the doors and all related hardware. This requirement ensures that no mistakes are made.

Table 1. Summary of corrosion prevention and control technologies implemented at Fort Bragg WTP and WWTP.

TASK	Applications	Plant	Material/coating	Source	Surface Profile Thicknesses (mils)	Attributes/Advantages	Required Time for each Task
1	Refurbish the concrete wall coating in the single filters	Water Treatment Plant	Mainstay ML-72 Microsilica Restoration Mortar/Mainstay 1103 coaltar epoxy (20-25 mils)/Mainstay DS-4 Epoxy(16 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	36-41	-Epoxy is high solids with no VOCs -Coating meets NSF-61 requirements for potable water	3 days/single cell filter
2	Refurbish the concrete in dual filters (2 cells/filter)	Water Treatment Plant	Mainstay ML-72 Microsilica Restoration Mortar/Mainstay 1103 coaltar epoxy (20-25 mils)/Mainstay DS-4 Epoxy(16 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	36-41	-Epoxy is high solids with no VOCs -Coating meets NSF-61 requirements for potable water	4 days/single cell filter
3	Refurbish the coating in the single filters on the metal troughs and wash piping	Water Treatment Plant	Mainstay ML-72 Microsilica Restoration Mortar/Mainstay 1103 coaltar epoxy (20-25 mils)/Mainstay DS-3 Epoxy(16 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	SSPC 10 36-41mils	-Epoxy is high solids with no VOCs -Coating meets NSF-61 requirements for potable water	4 days/dual cell filter
4	Coat the new wash piping in the dual filters	Water Treatment Plant	Mainstay DS-4 epoxy	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	SSPC 10 16 mils	-Epoxy is high solids with no VOCs -Coating meets NSF-61 requirements for potable water	1 day/dual cell filter

5	Refurbish the coating on the piping and valves in below ground pits:	Water Treatment Plant	Madewell 1103 coal tar epoxy (20 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199	SSPC 10 20-25 mils	-Epoxy is high solids with no VOCs	1 day/pit
6	Refurbish the coating on large, above ground piping manifold	Water Treatment Plant	Madewell 1103 Epoxy	7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	SSPC -10 35 mil	-Epoxy is high solids with no VOCs -Coating meets NSF-61 requirements for potable water	2 days
7	Refurbish the coating on electrical panel box	Water Treatment Plant	Madewell 1312S primer (10 mils)/Madewell 1450 Urethane (2 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167	13 mils	-Epoxy is high solids with no VOCs	2 days
8	Refurbish the coating on 40' tall yard light poles	Wastewater Treatment Plant	Madewell 1103 primer 20-25 mils/Madewell 1450 Urethane (2 mils)	7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	SSPC 10 23 mils	-Epoxy is high solids with no VOCs	2 days/pole
9	Refurbish the coating on remote valve hand wheels	Wastewater Treatment Plant	Madewell 1103 primer (20 mils)/Madewell 1450 Urethane (2-3 mils)	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167	SSPC 10 23 mils	-Epoxy is high solids with no VOCs	1hr/handwheel

10	Refurbish and seal stainless steel electrical motor control/circuit breaker panel boxes.	Wastewater Treatment Plant	Madewell 1312S primer (20 mils)/Madewell 1450 Urethane (2 mils)	Allied Corrosion Industries Inc 1550 Cobb Industrial Drive, NE Marietta, GA 30066 Phone: 770-425-1355 Fax: 770-425-1354 www.alliedcorrosion.com	SSPC 10 23 mils		
11	Replace one single and two double metal doors with FRP doors	Chlorine Building wastewater treatment plants	Tiger FRP Doors	Tiger Doors, LLC PO Box 70 Greensburg, PA 15601-0070 Tel: 402-346-4344 888-891-4416 Fax: 402-346-0561	N/A	-Doors are corrosion resistant -Doors are fire rated	
12	Replace remote valve hand wheels	Wastewater Treatment Plant	304 Stainless Steel / B26-535 Aluminum alloy*	Madewell Products Corporation 7561-A Industrial Court Alpharetta, GA 3004 Tel: 770475-8199 Fax: 770-475-8167 Email: www.madewell.com	N/A	Stainless Steel and aluminum alloy is corrosion resistant	

4 Metrics

Metrics for this project are based on verification of the atmospheric corrosivity of the Fort Bragg WTP and WWTP. A total of eight exposure racks were fabricated, with eight coupons per rack. The coupons were furnished by Metal Samples, Inc., with precise dimensions and weights recorded at the manufacturing laboratory. The coupons were constructed of mild carbon steel alloy A285-C. Each coupon was stamped with an identification number that corresponded to a precise factory obtained weight. The coupons each had an exposure surface of 12.3563 square inches, and an initial weight of 88 to 92 grams. The coupon racks were mounted at four locations each within both the WTP and the WWTP on October 25, 2005. The intent of the coupons is to be able to accurately monitor the corrosion rates in the various environments. The locations of these coupons are shown schematically in Appendix 5. Photographs of selected coupon racks are shown in Figures 13a, 13b, and 13c in Appendix 2.

Coupons will be removed from each rack every 4 months over the next 2 years. When the coupons are retrieved, the condition of the repaired structures will also be examined. Any degradation due to deficient materials and workmanship, witnessed over the first year, will be submitted to the contractor for repair.

At the WTP, the coupon racks were exposed at the following locations:

C P – 1 Above the sand filter basins
C P – 2 Submerged in a sand filter
C P – 3 Near the chlorination building
C P – 4 Near the outlet pumphouse

At the WWTP, the coupons were exposed at:

C P – 1 On a pole near sludge storage
C P – 2 On a wall near the inlet pumps
C P – 3 Submerged within the primary clarifier
C P – 4 On a pole near the effluent pumps

Exposure Results: The first set of coupons was retrieved on February 22, 2006. Each coupon was removed and placed in an envelope with the coupon number displayed. The coupons were then express shipped to Metal Samples, Inc. for laboratory analysis.

WTP
C P – 1 0.1 mils/year – Light
C P – 2 4.9 mils/year - General Pitting
C P – 3 0.88 mils/year - Spotty Etch
C P – 4 0.78 mils/year - Spotty Etch

WWTP
C P – 1 0.89 mils/year - Spotty Etch
C P – 2 0.42 mils/year - Spotty Etch
C P – 3 2.32 mils/year - General Pitting
C P – 4 0.79 mils/year - Spotty Etch

The second set of coupons was retrieved on July 7, 2006. The laboratory analysis of those coupons were:

WTP
C P – 1 0.27 mils/year - General Pitting
C P – 2 5.5 mils/year - Overall Attack
C P – 3 0.81 mils/year - General Pitting
C P – 4 0.64 mils/year - General Pitting

WWTP
C P – 1 0.79 mils/year - General Pitting
C P – 2 0.38 mils/year - General Pitting
C P – 3 3.5 mils/year - Overall Attack
C P – 4 0.78 mils/year - General Pitting

The third set of coupons was retrieved on November 1, 2006. The results of the laboratory analysis were:

WTP
C P – 1 0.44 mils/year - General Pitting
C P – 2 5.62 mils/year - Overall Attack

C P – 3 0.66 mils/year - General Pitting
C P – 4 0.56 mils/year - General Pitting

WWTP
C P – 1 0.68 mils/year - General Pitting
C P – 2 0.35 mils/year - General Pitting
C P – 3 3.4 mils/year - Overall Attach
C P – 4 0.69 mils/year - General Pitting

The rate of corrosion in atmospheric exposure throughout both plants is less than 1 mil/year. This level of corrosion generally would not compromise the structural integrity of most exposed equipment. However, the rate of corrosion is sufficient to affect the appearance of structures. The metal loss on both of the submerged coupons was significantly higher than those exposed in the atmosphere. It was interesting to note that the corrosion rate of metal loss in the filtered water was up to 65% higher than in the sewage water. The most significant corrosion observed on the actual WTP structures was on the submerged metal wiers and pipes in the filter basins.

5 Economic Summary

The projected return on investment (ROI) for this project was determined by assessment of the project costs and projected cost avoidance due to implementation in accordance with the recommended procedure based on Appendix B of OMB Circular A94. The ROI study prepared in the original Project Management Plan for AR-F-319 was validated, and concludes that the potential ROI for implementing advance materials and coatings is projected to be 14.4. Assumptions that support this project ROI are given in Appendix 6. The major basis of the ROI arguments are related to the reduction of maintenance costs by 15%. The ROI analysis was validated by an independent economic summary and ROI calculation by Allied Corrosion, Inc. which is also given in Appendix 6.

6 Recommendations

Based on the results of this project, the following corrosion prevention materials and coatings are recommended for approved by the American Water Works Association (AWWA) and the NSF Standard 61 for components affected by moderate concentrations of airborne chlorine gas that is used at WTPs and WWTPs:

1. Corrosion-resistant alloys for replacement of valve handles and valve stands
2. UV-resistant coatings for coating of components such as coal-tar epoxy primer and urethane topcoat for steel light posts and for wheel valves, valve stands, and pipes.
3. Microsilica restoration coatings for deteriorated concrete components, such as filter tanks, followed by a 100% solids, chemically modified epoxy coal tar top-coating according to NSF Standard 61.
4. Chemically modified, 100% solids epoxy coal tar coating with an epoxy coal tar topcoat for metal troughs in filter cells approved for potable water service according to the AWWA
5. Corrosion-resistant steels and nitrile gaskets and urethane coatings for electrical control and junction boxes
6. Corrosion-resistant FRP doors

It is recommended that the existing relevant UFGS be modified to include the industry and government specifications and instructions for implementing the corrosion prevention and control materials selection and coatings technologies demonstrated under this demonstration project.

7 Implementation

The technologies demonstrated and implemented under this project are recommended for Army and DoD Installations that own and operate potable WTPs and WWTPs. It is recommended that revisions to existing UFGS include the specifications and instructions for implementing the corrosion prevention and control materials selection and coatings technologies demonstrated under this CPC project. The applicable UFGS that are candidates for revisions are the materials selection sections in the following UFGS:

- UFGS 0997040 C-200 Coal Tar Epoxy Polyamide Paint
- UFGS 08120 Aluminum Doors and Frames
- UFGS 08165A Sliding Metal Doors
- UFGS 08710 Door Hardware
- UFGS 02510A Water Distribution System
- UFGS 16528A Exterior Lighting Including Security and CCTV Applications

Therefore, the materials selection technologies can be implemented Army-wide, and then expanded to the Navy and Air Force. Coordination with potential users is an essential part of the transition of the technology.

8 Conclusions

This CPC project has successfully demonstrated advanced materials and coating selection for use in the corrosive environments of WTPs and WWTPs. Coal-tar epoxy coatings were shown to be well suited in the presence of moderate concentrations of airborne chlorine and hydrogen sulfide gases that are routinely found in water and wastewater treatment facilities. Microsilica cement mortar applied to the filter tanks forms a high-strength moisture barrier with extremely low permeability and a strong chemical/mechanical bond to brick and cementitious substrates. FRP doors of phenolic honeycomb core construction with exclusive press molding technology yield an excellent mechanical durability and superior resistance to sunlight, moisture, and chemicals, and carry a lifetime warranty as it specifically relates to de-lamination or corrosion.

All the different tasks under this contract were completed successfully, resulting in the significant life extension of all the structures involved. These CPC technologies are applicable to other WTPs and WWTPs within the Army and DoD, and can be expected to result in restoration of the plants to optimum operating conditions at significant cost avoidance. It is recommended that existing UFGS and TMs be modified to include the industry and Government specifications and instructions for implementing the corrosion prevention and control materials selection and coatings technologies demonstrated.

Appendix 1: Contractor Submittals

Submittals
TASK DESCRIPTIONS
PART LISTS
SUBMITTALS
For
Fort Bragg Project No.: AR-F-319
July 20, 2005

Fresh Water Treatment Plant Tasks

Task No. 1-B

Description and Parts List

Task: Sandblast to SSPC-10 and coat the metal troughs, including the small diameter pipe associated with the surface sweep system with corrosion-resistant coating in six single-cell filter tanks (16’ long x 12’ wide x 14’ deep).

Work Sequence:

ACI has subcontracted the task to Steel and Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. In the Fresh Water Treatment Plant, Steel & Sons will sandblast to SSPC 10 and coat the metal troughs and surface wash metal components with two (2) coats of Mainstay DS 3 Epoxy Coating to an average thickness of 16 mils, in six (6) single-cell fresh water filter tanks.

2. The coating is approved for potable water service according to NSF Standard 61.

Parts List:

1. Coating: Mainstay DS-4

Task No. 1-C

Description and Parts List

Task: Design and install cathodic protection for metal troughs and surface wash components using sacrificial anodes in six (6) single cell filter tanks (16" long x 12' wide x 14' deep).

Work Sequence:

This part of the original project has been canceled.

Task No. 1-D

Description and Parts List

Task:

Sandblast to SSPC 10 and coat seven (7) dual-cell filter surface wash piping systems. This amounts to fourteen (14) separate piping systems.

Work Sequence:

ACI has subcontracted the task to Steel and Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. In the Fresh Water Treatment Plant, Steele & Sons will sandblast to SSPC 10 and coat the surface wash metal components with two (2) coats of Mainstay DS-4 Epoxy Coating to an average thickness of 16 mils, in seven (7) dual-cell fresh water filter tanks.

2. The coating is approved for potable water service according to NSF Standard 61.

Parts List:

Please note that the items below are identical to those items under Task No. 1-B, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Coating: Mainstay DS-4

Task No. 1-E

Description and Parts List

Task:

Refurbish concrete surfaces on three (3) single cell filter tanks 1 - 3 with metallic troughs using a concrete restoration and corrosion barrier compound.

Work Sequence:

ACI has subcontracted the task to Steel and Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Steele & Sons will have the concrete surfaces of three (3) of the single-cell fresh water filter tanks refurbished. This will be done with Madewell's Mainstay Composite Liner rehabilitation and corrosion protection system. This process begins by pressure washing the concrete substrates and removing all loose concrete down to sound concrete, and removing all contaminants.

2. Mainstay ML-72 sprayable microsilica restoration mortar is then applied to the saturated concrete substrates to an average thickness of ½". After the mortar has achieved its initial set (usually in 1 to 3 hours), Madewell 1103 Epoxy Coal Tar Coating is spray applied to the mortar to an average thickness of 25 mils (~ 1/32").

3. After overnight cure, these tanks will be top-coated with Mainstay DS-4 Epoxy Coating

to minimum thickness of 16 mils in two (2) coats. This coating is approved for potable water service according to NSF Standard 61.

4. After 24 hours of cure at 73 °F, these tanks can be put into service.

Parts List:

1. Mortar: Madewell's Mainstay ML-72
2. Intermediate Coating: Madewell 1103
3. Outer Coating: Madewell's Mainstay DS-4

Task No. 1-F

Description and Parts List

Task: Refurbish concrete surfaces of two (2) dual-cell filter tank numbers 7 - 8 with concrete troughs using concrete restoration and corrosion barrier compound.

Work Sequence:

ACI has subcontracted the task to Steel and Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Steele & Sons will have the concrete surfaces of two (2) of the dual-cell fresh water filter tanks refurbished. This will be done with Madewell's Mainstay Composite Liner rehabilitation and corrosion protection system. This process begins by pressure washing the concrete substrates and removing all loose concrete down to sound concrete, and removing all contaminants.

2. Mainstay ML-72 sprayable microsilica restoration mortar is then applied to the saturated concrete substrates to an average thickness of ½". After the mortar has achieved its initial set (usually in 1 to 3 hours), Madewell 1103 Epoxy Coal Tar Coating is spray applied to the mortar to an average thickness of 25 mils (~ 1/32").

3. After overnight cure, these tanks will be top-coated with Mainstay DS-4 Epoxy Coating to minimum thickness of 16 mils in two coats. This coating is approved for potable water service according to NSF Standard 61.

4. After 24 hours of cure at 73 °F, these tanks can be put into service.

Parts List:

Please note that the items below are identical to those items under Task No. 1-E, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Mortar: Madewell's Mainstay ML-72
2. Intermediate Coating: Madewell 1103
3. Outer Coating: Madewell's Mainstay DS-4

Task No. 1-G

Description and Parts List

Task: Refurbish concrete surfaces on three (3) single cell filter tanks 4 - 6 with metallic troughs using a concrete restoration and corrosion barrier compound.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Steel & Sons will have the concrete surfaces of three (3) of the single-cell fresh water filter tanks refurbished. This will be done with Madewell's Mainstay Composite Liner rehabilitation and corrosion protection system. This process begins by pressure washing the concrete substrates and removing all loose concrete down to sound concrete, and removing all contaminants.

2. Mainstay ML-72 sprayable microsilica restoration mortar is then applied to the saturated concrete substrates to an average thickness of ½". After

the mortar has achieved its initial set (usually in 1 to 3 hours), Madewell 1103 Epoxy Coal Tar Coating is spray applied to the mortar to an average thickness of 25 mils (~ 1/32”).

3. After overnight cure, these tanks will be top-coated with Mainstay DS-4 Epoxy Coating to minimum thickness of 16 mils in two (2) coats. This coating is approved for potable water service according to NSF Standard 61.

4. After 24 hours of cure at 73 °F, these tanks can be put into service.

Parts List:

Please note that the items below are identical to those items under Task No. 1-E, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Mortar: Madewell’s Mainstay ML-72
2. Intermediate Coating: Madewell 1103
3. Outer Coating: Madewell’s Mainstay DS-4

Task No. 1-H

Description and Parts List

Task: Refurbish concrete surfaces of two (2) duel-cell filter tank numbers 9 - 10 with concrete troughs using concrete restoration and corrosion barrier compound.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products.

Their work sequence is as follows:

1. Steele & Sons will have the concrete surfaces of two (2) of the dual-cell fresh water filter tanks refurbished. This will be done with Madewell’s Mainstay Composite Liner rehabilitation and corrosion protection system.

This process begins by pressure washing the concrete substrates and removing all loose concrete down to sound concrete, and removing all contaminants.

2. Mainstay ML-72 sprayable microsilica restoration mortar is then applied to the saturated concrete substrates to an average thickness of ½". After the mortar has achieved its initial set (usually in 1 to 3 hours), Madewell 1103 Epoxy Coal Tar Coating is spray applied to the mortar to an average thickness of 25 mils (~ 1/32").

3. After overnight cure, these tanks will be top-coated with Mainstay DS-4 Epoxy Coating to minimum thickness of 16 mils in two (2) coats. This coating is approved for potable water service according to NSF Standard 61.

4. After 24 hours of cure at 73 °F, these tanks can be put into service.

Parts List:

Please note that the items below are identical to those items under Task No. 1-E, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Mortar: Madewell's Mainstay ML-72
2. Intermediate Coating: Madewell 1103
3. Outer Coating: Madewell's Mainstay DS-4

Task No. 1-J

Description and Parts List

Task: Sandblast to SSPC 10 and coat one (1) large-diameter piping manifold behind the Fresh Water Treatment Plant.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products.

Their work sequence is as follows:

1. Behind the Fresh Water Treatment Plant, Steele & Sons will sandblast to SSPC 10 and coat the large-diameter piping manifold with two (2) coats of Madewell 1103 Epoxy Coal Tar coating to an average thickness of 16 mils.

Parts List:

Please note that the items below are identical to those items under Task No. 1-E, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Coating: Madewell 1103

Task No. 1-K

Description and Parts List

Task: Sandblast to SSPC-10 two electrical control boxes behind the Fresh Water Treatment plant with Madewell 1312S – White epoxy under coating and a top coating of Madewell 1450 sealcoat.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Sandblast the exteriors of two (2) electrical control boxes to near-white metal condition (SSPC-10/ NACE 2)

2. Coat all sandblasted areas with one coat of Madewell 1312S White Epoxy Coating to a dryfilm thickness of 10 mils. Upon curing to a tack free condition, apply one coat of Madewell 1450 (White) Urethane Coating to a dry film thickness of 2 mils.

Parts List:

1. Coating: Mainstay 1312S

2. Coating: Madewell 1450

Fort Bragg Project No.: AR-F-319

9. Task No. 1-L

Description and Parts List

Task: Sandblast to SSPC 10 and coat the external surface of large-diameter piping in nineteen (19) valve pits located behind the Fresh Water Treatment Plant. Fort Bragg will remove all soil, vegetation, water, mud, and debris from the valve pits prior to our mobilization to initiate this task.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products.

Their work sequence is as follows:

1. Behind the Fresh Water Treatment Plant, Steele & Sons will sandblast to SSPC 10 and coat the external surface of the large-diameter piping in nineteen (19) valve pits with one coat of Madewell 1103 Coal Tar Epoxy Coating to an average thickness of 25 mils.

Parts List:

Please note that the items below are identical to those items under Task No. 1-E, consequently the literature submittals are identical, and were not resubmitted under this Task.

1. Coating: Madewell 1103

Wastewater Treatment Plant Tasks

Task No. 2-A

Description and Parts List

Task: Sandblast seventeen (17) steel light posts to SSPC 10 and coat with coal tar epoxy base coat and urethane topcoat.

Work Sequence:

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Steele & Sons will sandblast seventeen (17) steel light posts to SSPC 10 and coat with Madewell 1103 Epoxy Coal Tar Coating to minimum thickness of 25 mils, followed by one coat of Madewell 1450-Dark Bronze to a dry film thickness of 2.0 mils.

Parts List:

1. Coating: Madewell 1103
2. Coating: Madewell 1450
2. Fort Bragg Project No.: AR-F-319

Task No. 2-B

Description and Parts List

Task: Sandblast and coat the following items:

1. Sand blast and coat nineteen (19) remote-valve, operating hand wheels with coal-tar epoxy or other suitable corrosion-resistant coating in the area next to screw pumps and in the area between the Continuous Loop Reactors.

2. Replace three (3) remote-valve, operating hand wheels.

3. Sandblast and coat eleven (11) remote valve operator stands in the area next to screw pumps and in the area between the Continuous Loop Reactors.

Work Sequence:

1. ACI will install three (3) new hand wheels where the hand wheels are not salvageable because of severe corrosion.

2. Once installed, all hand wheels and remote valve operator stands will be coated by Steele & Sons using Madewell products.

ACI has subcontracted the task to Steele & Sons, Inc., who will be using Madewell products. Their work sequence is as follows:

1. Steele & Sons will sandblast nineteen (19) remote valve operating hand wheels and eleven (11) remote valve operator stands to SSPC 10.

2. They will then coat the nineteen (19) hand wheels with Madewell 1103 Epoxy Coal Tar Coating to minimum thickness of 25 mils. The eleven (11) remote valve operator stands will be coated first with Madewell 1103 Epoxy Coal Tar Coating to minimum thickness of 25 mils, followed by one coat of Madewell 1450-Silver to a dry film thickness of 2.0 mils.

Parts List:

1. Valve Hand Wheel: Rodney Hunt Company - Part No.: D7505-01

Please note that the items below are identical to those items under Task No. 2-A, consequently the literature submittals are identical, and were not resubmitted under this Task.

2. Coating: Madewell 1103
3. Coating: Madewell 1450 - Silver

Fort Bragg Project No.: AR-F-319

Task No. 2-C

Description and Parts List

3. Task: Replace three (3) steel doors with corrosion-resistant fiber-reinforced plastic (FRP) doors in the chlorine storage building located at the Wastewater Treatment Plant.

Work Sequence: ACI has subcontracted this task to Engineering Specialties, Inc. Their work sequence is as follows:

1. Remove old steel doors.
2. Perform inspections & minor repairs/ adjustments to remaining frames.
3. Prepare frames for receipt of hinges, which are already installed on the doors.
4. Install factory-prepared, ready-to-install, Tiger Doors
5. Perform necessary inspections/ minor adjustments/ alignments.
6. Clean up work site.

Parts List:

All doors are factory-milled and mortised. All hardware is factory installed.

1. Two (2) Single Tiger Doors, 3’ x 7’, factory-prepared for ease of installation.

2. Four (4) Double Tiger Doors, (8 Pcs, 5’ x 10’), factory-prepared for ease of installation.

Task No. 2-D

Description and Parts List

Task: Refurbish ten (10) existing electrical control boxes. This refurbishment is to include the following:

1. Install, where necessary, new stainless steel latches with stainless steel hardware.
2. Install PVC fitting at the conduit enclosure entry points, where practical.
3. Install Chico A-05 in all conduit openings where practical.
4. Install new chemical resistant door gaskets.
5. Coat all metal conduit items with PVC coating.

Work Sequence:

1. Turn off the power to the electrical enclosure to be refurbished.

2. Disconnect all electrical wiring inside the enclosure and mark all wires appropriately.

3. Remove enclosure from wall.

4. Clean the inside of the enclosure.

5. Remove the old steel conduit fitting entering into the enclosure and replace it with duplicate PVC fitting where practical.

6. Coat all metal conduit components with PVC coating.

7. Remove old gasket and clean surface where old gasket was located.

8. Install new chemical resistant gasket.

9. Remount the enclosure on the wall with stainless steel fasteners.

10. Replace old latches, where needed, with new stainless steel latches.

11. Remove all aluminum pop rivets and replace with new stainless steel hardware.

12. Install the Chico A-05 conduit sealant into all conduit openings where practical. On those conduits that enter the enclosure from the side or top, seal these with polyurethane foam.

13. Reconnect the wiring to the appropriate terminals.

14. Turn the power back on to the enclosure and check its functionality.

Parts List:

1. Gasket: Nitrile Degradation – Resistant Seals

2. Chico A-05 Sealing Compound

3. Polyurethane Foam: DAP KWIK Foam Polyurethane Insulating Sealant

Appendix 2: Photographs of Components at Water and Wastewater Treatment Plants Journal

Water treatment plant

TASK NO. A1

Refurbish the concrete surfaces within six (6) single cell water filters.

Figure 1a. Concrete surface in single cell water filter before refurbishment.

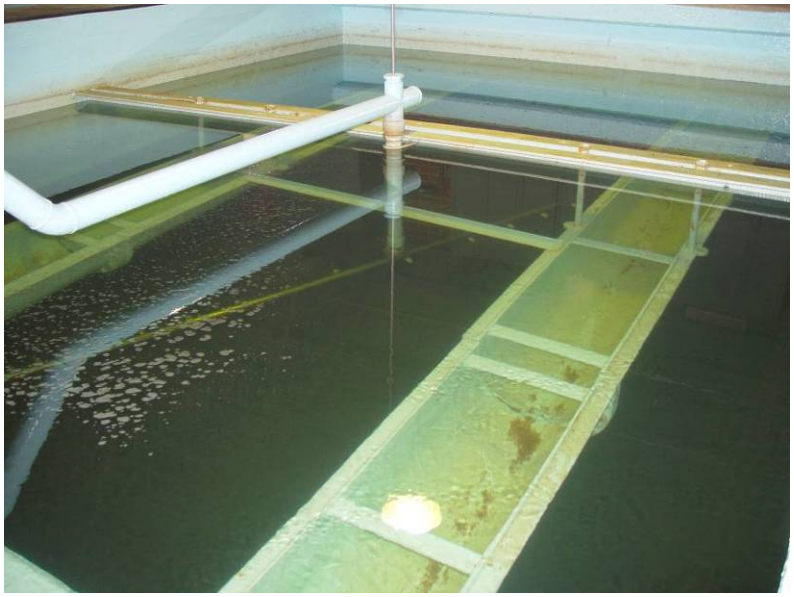


Figure 1b. Concrete surfaces in single cell water filter after refurbishment.

TASK NO. A2

Refurbish the concrete surfaces within seven (7) dual cell water filters.

Figure 2a. Concrete surface in dual cell water filter before refurbishment.

Figure 2b. Concrete surface in dual cell water filter after refurbishment.

TASK NO. A3

Refurbish the coating on the metal troughs and wash piping on the six (6) single filter cells.

Figure 3a. Metal troughs and wash piping in single filter cells before coating refurbishment.

Figure 3b. Metal troughs and wash piping in single filter cells after coating refurbishment.

TASK NO. A4
Coat the newly installed wash piping in the four (4) dual filter cells

Figure 4a. Newly installed wash piping in dual filter cells before refurbishment.

Figure 4b. Newly installed wash piping in dual filter cells after refurbishment.

TASK NOs.
A5. Refurbish the coating system on nineteen (19) underground valve pits;

A6. Refurbish the coating system on one (1) large above ground manifold

Figure 5. New coating system on one of nineteen underground valve pits.

Figure 6. New coating system on above-ground manifold.

TASK NO. A7

Refurbish the coating system on two (2) electrical panel boxes for the recirculation pumps

Figure 7. Electrical boxes at water treatment plant after refurbishment.

Wastewater treatment plant

TASK NO. B1
Refurbish coating system on 17 steel light poles

Figure 8a. Typical steel light pole at wastewater treatment plant before refurbishment.

Figure 8b. Typical steel light pole at wastewater treatment plant after refurbishment.

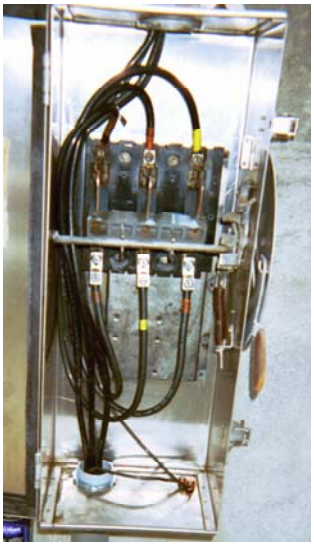
TASK NO. B2
Refurbish the coating system of nineteen (19) hand wheels and operator stands

Figure 9a. Hand wheels and operator stands before refurbishment at wastewater treatment plant.

Figure 9b. Hand wheels and operator stands at wastewater treatmentplant after refurbishment.

TASK NO. B3
Refurbish electrical boxes

Figure 10a. A typical electrical control box before refurbishment.



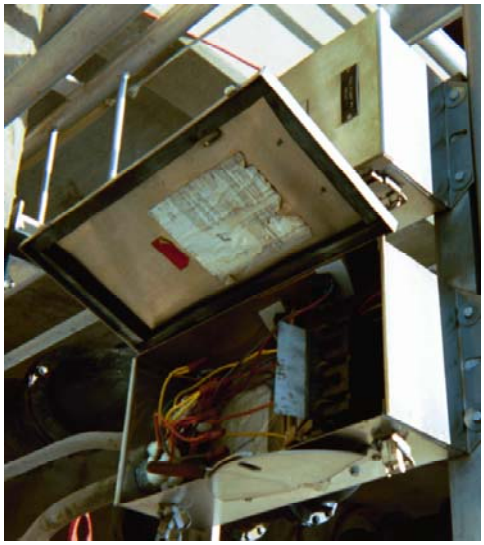


Figure 10b. Electrical control boxes at wastewater treatment plant with nitrile gaskets after refurbishment.

TASK NO. B4

Replace Corroded doors on Chlorine Storage Building

Figure 11a. Typical steel door at chlorine building at wastewater treatment plant before refurbishment.

Figure 11b. Typical steel door at chlorine building at wastewater treatment plant after refurbishment.

TASK NO. B5
Replace three (3) badly corroded operating valve hand wheels that were unsalvageable.

Figure 12a. Severely corroded (un-salvageable) corroded steel hand wheels at WWTP before replacement.

Figure 12b. New hand wheels (aluminum alloy B26-535) at WWTP replacing the corroded steel hand wheels shown in Figure 12a.

Figure 13a. Above water weight loss coupon at WTP.

Figure 13b. Atmospheric weight loss coupons at WTP.

Figure 13c. Atmospheric weight loss coupons at WWTP.

Appendix 3: National Sanitation Foundation (NSF) Standard NSF-61

This information will help explain the purpose, scope, and content of NSF/ANSI Standard 61.

1. NSF/ANSI Standard 61 Drinking Water System Components - Health Effects is the standard that establishes minimum health effects requirements for the chemical contaminants and impurities that may be indirectly imparted to drinking water. The standard provides the criteria used to evaluate the public health safety of materials, components, products, or systems that contact drinking water, drinking water chemicals, or both.
2. NSF/ANSI Standard 61 (NSF 61) covers many items, including, but are not limited to:
    a. Plastic materials, plastic and metal pipe and related products (fittings, tanks, etc.)
    b. Protective materials (coatings, linings, liners, cement, cement ad-mixtures, etc.)
    c. Joining and sealing materials (adhesives, lubricants, elastomers, etc.)
    d. Process media (carbon, sand, ion exchange resin, etc.)
    e. Treatment/transmission/distribution devices (valves, pumps, filters, chlorinators, etc.)
    f. End-point devices (faucets, end-point control valves, etc.)
3. NSF/ANSI Standard 61 does not address all aspects of product use. The standard is focused and limited to addressing potential health effects except where specific application and performance standards are referenced. Some items not addressed by this standard are performance (such as burst pressure), taste and odor, microbiological growth support, and electrical safety. Other standards may address these aspects of products.
4. NSF/ANSI Standard 61 is divided into nine Sections and four Annexes as noted below.
    a. Section 1= Purpose, Scope, Limitations, Normative References of the standard
    b. Section 2= Definitions of various terms (note there are more definitions in sections 4 through 9 and Annex A)
    c. Section 3= General requirements, required information, review of formulations, minimum testing batteries, etc.

d. Section 4= Specific requirements for Pipe and related products like PVC, PE, Cu, Fe, etc. pipe, fittings, and potable water materials
e. Section 5= Specific requirements for Protective Barrier Materials/products such as sealers, coatings, paint, primer, mortar, Portland cements, cement ad-mixtures, etc.
f. Section 6= Specific requirements for Joining and Sealing Materials/products such as o-rings, gaskets, lubricants, adhesives, elastomer materials, etc.
g. Section 7= Specific requirements for Process and filtration media products such as ion exchange, activated carbon, sand, manganese, aluminum silicates, etc.
h. Section 8= Specific requirements for Mechanical Devices products such as filters, valves, pumps, chemical generators, chemical feeders, etc.
i. Section 9= Specific requirements for Mechanical Plumbing Devices such as faucets and other end point devices
j. Annex A= Toxicology Review and Evaluation Procedures (risk assessment and normalization details)
k. Annex B= Detailed product/material evaluation information (details of test waters for rinse, conditioning, exposure, etc.)
l. Annex C= Acceptable Materials, details of existing types (such as certain stainless steel materials) and how to add new ones
m. Annex D= Normative drinking water criteria (USEPA, Health Canada, NSF etc. derived short and long term exposure limits)

Source: http://www.nsf.org/business/water_distribution/standard61_overview.asp?program=WaterDistributionSys

Material suppliers

The materials and services listed above may be purchased from the following companies:

Allied Corrosion Industries, Inc.
PO Box 9098
Marietta, GA 30065-2098
Tel: 770-425-1355
800-241-0809
Fax: 770-425-1354
Email: info@alliedcorrosion.com

Madewell Products Corporation
7561-A Industrial Court
Alpharetta, GA 3004
Tel: 770475-8199
Fax: 770-475-8167
Email: www.madewell.com

Tiger Doors, LLC
PO Box 70
Greensburg, PA 15601-0070
Tel: 402-346-4344
888-891-4416
Fax: 402-346-0561
Email: www.tigerdoor.com

Product data sheets

DS5084B

Madewell® 1103

Epoxy Coal Tar Coating

Madewell®
"THE NAME SAYS IT ALL."

FEATURES/BENEFITS

PERMANENT FLEXIBILITY	SUNLIGHT/ULTRAVIOLET RESISTANCE
TEMPERATURE RESISTANCE IN IMMERSION	ABRASION RESISTANT
SUPERIOR CHEMICAL RESISTANCE	100% SOLIDS
IMPACT RESISTANT	HIGH BUILD
EXCELLENT ADHESION	LOW TEMPERATURE/HIGH MOISTURE CURE

PRODUCT DESCRIPTION

MADEWELL® 1103, A 100% solids, chemically modified epoxy coal tar coating, represents a major breakthrough in the performance of epoxy coal tar systems. Its unique, multicomponent curing system contributes to a number of superior properties: toughness, permanent flexibility, and improved chemical and temperature resistance. This sprayable system may be applied in thickness up to 40 mils or more in a single application, which reduces application costs. The absence of solvent reduces shrinkage, cracking and disbonding and eliminates the problems related to solvent entrapment. The system remains quite flexible when mixed with select siliceous fillers (up to 100% by weight). MADEWELL 1103 cures relatively fast at 40° F and under high moisture conditions - even under water. This property enables field applications under a variety of weather conditions resulting in minimum downtime. MADEWELL 1103 exhibits superior ultraviolet and sunlight resistance after years of exposure. Common chalking, checking, and embrittlement problems associated with traditional epoxy coal tar systems are not present with this system.

MADEWELL 1103 meets the requirements of: The U.S. Environmental Protection Agency's extractables protocol for coatings to be used in potable water service. The American Society for Testing and Materials (ASTM) Specification C-541. Performance criteria for the American Water Works Association Specification C-210.

PRODUCT DATA

COMPOSITION:
100% Solids, modified epoxy coal tar coating.

AVAILABLE COLORS:
Black or red.

THICKNESS:
20 to 125 mils (0.5 to 3.0 mm). Consult Madewell Technical Service Representative for specific recommendations.

COVERAGE:
80 ft² per gallon at 20 mils, theoretical. Allowances must be made for waste and shrinkage due to crosslinking.

PACKAGING:
Normally stocked in 50 lb. two component kits (approximately 4.5 gal. per kit). Larger and smaller kit sizes available on special order.

SURFACE PREPARATION:
Steel: Apply only to clean surfaces. All metal surfaces should be inspected prior to blast cleaning, and degreased or otherwise decontaminated, as required. New steel should be abrasive blast cleaned to a Commercial Blast condition in accordance with NACE TM-01-70 No. 3 or SSPC SP-6, 63 or pickled in accordance with SSPC SP-8, 63. Anchor pattern depth should be selected to fit the application, however, a 2 to 4 mil profile is suitable in most cases.

Concrete and Other Cementitious Surfaces: Concrete surfaces to be coated shall be free of laitance, grease, oil, and all other foreign materials. If required, the surfaces may be cleaned by sandblasting or other suitable mechanical means. Etching with muriatic acid may also be used to clean the surface, provided, however, that it is thoroughly broomed and flushed with a spray of fresh water to remove all salts. Surfaces need not be completely dry but should be free of standing or flowing water when MADEWELL 1103 is applied. If surfaces are extremely porous, weak or

deteriorated, MADEWELL 927 Primer should be used to penetrate, seal and strengthen the surface prior to coating. See descriptive brochure. Rough or deteriorated concrete should be smoothed and/or repaired using either Mainstay ML-72 Sprayable Microsilica Mortar or Madewell 1312P Thixotropic Epoxy Putty. Refer to the applicable descriptive brochure for surface preparation and application instructions.

MIXING RATIO:
Mix components at a weight ratio of 3 parts A to 7 part B.

POT LIFE:
Approximately 45 minutes at 100° F. Pot life will be extended at lower temperatures and shortened when higher.

THINNING:
Thinning is not recommended for topcoats. Use MADEWELL 457 THINNER for equipment cleanup (see descriptive brochure).

PRIMING:
Not necessarily required for steel surfaces. However, product may be thinned 10% to 15% by volume with MADEWELL 457 THINNER and applied as a primer for certain purposes (such as holding a blast condition or to promote wetting out of the surface in cool weather). Consult a Madewell Technical Service Representative for procedures particular to your application. Concrete surfaces may be primed with MADEWELL 927 PENETRATING EPOXY PRIMER-SEALER - see descriptive brochure for application and surface preparation details.

APPLICATION:
This product is to be applied by trained workmen using specialized equipment. Both components must be preheated to 100° F prior to application. A 45:1 airless spray pump at an air input pressure of ~90 PSI, is used to feed material through up to 50' of 1/2" diameter hose to a to a standard airless spray gun with a .031" to .035" reversible tip. It is recommended that 60 mesh in line strainers/filters be used. Other equipment, such as whip hoses, heaters or plural component equipment may be employed. Contact a Madewell technical service representative for specific equipment recommendations and sources.

NUMBER OF COATS:
Depends on service requirements. Generally speaking, linings or coatings for immersion service should be holiday free. The number of coats required to attain a holiday free lining or coating may vary depending on surface profile or roughness. Single coat applications should be done in multiple passes, each made at right angles to the last.

CURE TIME:
To handle - 36 hours at 70° F. Chemical or immersion service - 24 hours to 7 days, depending on temperature. If desired, or for certain chemical or high temperature applications, force curing for 8 hours at 140° F or higher may be employed. Contact a Madewell Technical Service Representative for specific recommendations.

CLEAN UP:
MADEWELL 457 THINNER is recommended to clean equipment (see descriptive brochure). Skin should be cleaned using warm soapy water or commercial hand cleaner.

STORAGE:
Store components in sealed containers in dry environment at moderate temperature conditions (< 80° F).

SHELF LIFE:
1 year, subject to reinspection thereafter.

SAFETY:
MADEWELL 1103 contains epoxy resins that *MAY CAUSE EYE OR SKIN SENSITIZATION*. Adequate health and safety precautions should be observed during all storage, handling, use and drying periods. For best results and safest usage, user is specifically directed to consult the current "Material Safety Data Sheet" for this product. When using this product in a confined space or closed area, consult the current OSHA or ANSI bulletins on safety requirements. Do not take internally. If swallowed, call a physician immediately. Keep away from open flame and keep containers tightly closed when not in use.

WARRANTY
All technical data, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowledge, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by the Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate or intended to suggest infringement of any existing patent. MADEWELL PRODUCTS CORPORATION MAKES NO GUARANTEE OR WARRANTIES EXCEPT AS OTHERWISE PROVIDED IN WRITING, AND DISCLAIMS ANY AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

® Jiffy is a registered trademark of the Jiffy Mixer Company.

DB5201A

Mainstay® ML-72

Sprayable Microsilica Cement Mortar

Madewell®
"THE NAME SAYS IT ALL"

FEATURES/BENEFITS

LOW PERMEABILITY
HIGH EARLY AND ULTIMATE STRENGTH
EASY TO USE AND FINISH
WATERPROOFS/DAMPPROOFS
VERY LOW SHRINKAGE
HIGH FLEXURAL AND BOND STRENGTH
HIGH BUILD - UP TO 5" PER PASS
RESTORES DETERIORATED SURFACES

PRODUCT DESCRIPTION

MAINSTAY® ML-72 is a blend of special cements, microsilica, thermoplastic fiber, densifiers, polymer admixtures and other modifiers that produces a high strength, low shrinkage and low permeability mortar for rehabilitation of deteriorated concrete structures. MAINSTAY ML-72 produces excellent adhesion to properly prepared existing concrete or brick surfaces. MAINSTAY ML-72 restores structural integrity, seals rough deteriorated surfaces and resists external hydrostatic water pressure. MAINSTAY ML-72 is suitable for permanent water immersion service.

MAINSTAY ML-72 can be used to repair floors, vertical and overhead surfaces of deteriorated concrete structures such as sewer pipes, pits, sumps, trenches, tunnels, bridges, piers or any concrete structure that has experienced deterioration from exposure to aggressive environments. This product is available without polymer additives, Mainstay ML-72B, for applications which remain continually wet during and after cure.

PRODUCT DATA

COMPOSITION:

A proprietary mixture of special cements, silica fume, thermoplastic fibers, polymer and modifiers. (MAINSTAY ML-72B does not contain polymer admixture.)

COLOR:

Dark Grey.

YIELD:

.625 ft^3 per 75# bag when mixed correctly.

COVERAGE:

Approximately 7.5 ft^2 per bag at 1" or 15 ft^2 per bag at 1/2". Allowances should be made for waste.

RECOMMENDED THICKNESS:

Depends on the application. 1" is generally sufficient for smoothing concrete which has experienced surface attack (exposed aggregate). Minimum thickness is usually 1/2". Consult a Madewell Technical Representative for specific recommendations.

PACKAGING:

Normally stocked in 75 pound bags.

SURFACE PREPARATION:

Prepare surfaces to be repaired by water blasting, abrasive blast, hand or power tool to remove all unsound concrete, contaminants, dirt, debris and/or deteriorated reinforcing steel. Refer to the International Concrete Repair Institute technical guideline titled "Surface Preparation Guidelines For The Repair Of Deteriorated Concrete Resulting From Reinforcing Steel Oxidation" and/or contact your Mainstay Representative for information on removal techniques that are best for your application. Surfaces should have a minimum profile of 1/16" (preferably with aggregate exposed) and should be inspected for soundness prior to application of MAINSTAY ML-72. Saturate all surfaces thoroughly with clean fresh water prior to application and allow to surface dry just prior to application of MAINSTAY ML-72.

MIXING:

Add 1.5 gallons of fresh clean water per 75# bag. Mix thoroughly using a gasoline or electric powered paddle-type mixer.

APPLICATION:

MAINSTAY ML-72 can be applied by low to medium velocity wet mix shotcrete equipment (pneumatic spray) or by hand using a trowel. Application thicknesses up to 5" in a single lift are possible depending on the amount of water added, the condition of the surfaces being treated and jobsite conditions. A variety of piston, systolic and rotor/stator pumps may be used depending on job requirements and desired production rates. Consult your Mainstay representative for information regarding equipment that is best suited for your job.

Madewell Products Corporation • 7561A Industrial Court • Alpharetta, GA 30004 • Voice: (770) 475-8199 • Fax: (770) 475-8167

WORKING TIME:
Approximately 30 minutes at 80° F. The working time will be extended somewhat at lower temperatures and shortened at higher temperatures.

FINISHING:
Mainstay ML-72 can be finished using a steel trowel, wood float, sponge float, broom or brush, depending on the surface texture desired. If Mainstay ML-72 is to be topcoated, it is recommended that the surface be finished to a smooth, somewhat grainy texture using a sponge or wood float.

CURING:
If applicable, MAINSTAY ML-72 should be topcoated immediately after finishing, as soon as the surface becomes firm to the touch. If not topcoated, Mainstay ML-72 should be kept moist with fresh clean water for the first 72 hours after placement.

CLEAN UP:
Clean up equipment and tools with clean tap water.

STORAGE:
Store MAINSTAY ML-72 in a cool dry place.

Compressive Strength ASTM C-109 (modified)	2 days 7 days 14 days 28 days	3875 psi 4550 psi 5640 psi 6190 psi
Flexural Strength	7 days 28 days	790 psi 935 psi
Tensile Strength	7 days 28 days	290 psi 575 psi
Shrinkage ASTM C-157	28 days	0.04%
Bond* (uniaxial tension)	28 days	>500 psi

*Uniaxial tensile bond strength should achieve a minimum of 1 Newton/mm² (145 psi) over a sound, properly prepared substrate. However, bond is highly dependent on degree of surface preparation and substrate strength.

SHELF LIFE:
1 year, subject to reinspection thereafter.

SAFETY:
MAINSTAY ML-72 contains portland cement and chemicals which *MAY CAUSE EYE OR SKIN SENSITIZATION.* Adequate health and safety precautions should be observed during all storage, handling, use and drying periods. For best results and safest usage, user is specifically directed to consult the current "Material Safety Data Sheet" for this product. When using this product in a confined space or closed area, consult the current OSHA or ANSI bulletins on safety requirements. Do not take internally. If swallowed, call a physician immediately.

WARRANTY
All technical data, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowledge, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by the Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate or intended to suggest infringement of any existing patent. MADEWELL PRODUCTS CORPORATION MAKES NO GUARANTEE OR WARRANTIES EXCEPT AS OTHERWISE PROVIDED IN WRITING, AND DISCLAIMS ANY AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

DS4344B

Mainstay® DS-4

Ultra High Build Epoxy Coal Tar Coating

Madewell®
"THE NAME SAYS IT ALL"

FEATURES/BENEFITS

PERMANENT FLEXIBILITY | SUPERIOR CHEMICAL RESISTANCE
ABRASION RESISTANT | HIGH MOISTURE CURE
VERY HIGH BUILD | IMPACT RESISTANT

PRODUCT DESCRIPTION

MAINSTAY® DS-4 is a 100% solids, chemically modified epoxy coal tar coating utilizing a unique, multi-component curing system which contributes to a number of superior properties: toughness, permanent flexibility, and improved chemical and temperature resistance. This sprayable system may be applied at thicknesses up to 100 mils or more in a single application, thereby reducing application costs. The absence of solvent reduces shrinkage, cracking and disbonding and eliminates the problems related to solvent entrapment. MAINSTAY DS-4 cures relatively fast at 40° F and under high moisture conditions - even under water. This property enables field applications under a variety of weather conditions resulting in minimum downtime. MAINSTAY DS-4 exhibits superior ultraviolet and sunlight resistance after years of exposure. MAINSTAY DS-4 is particularly well suited for use as a topcoat over MAINSTAY ML-72 Microsilica Cement Mortar (see section on Application).

PRODUCT DATA

COMPOSITION:
100% solids, modified epoxy coal tar coating.

FINISH:
Gloss

COLOR:
Black.

THICKNESS:
50 to 125 mils in one or two coats. Consult a Madewell technical representative for specific recommendations.

COVERAGE:
Approximately 16 ft² per gallon at 100 mils. Allowances should be made for waste.

PACKAGING:
Normally stocked in 4.5 gallon two component kits. Larger and smaller kits are available on special order.

SURFACE PREPARATION:
Concrete: Concrete surfaces should be primed with MADEWELL 927 Penetrating Epoxy Primer/Sealer. See descriptive brochure for surface preparation and application instructions.

Rough or deteriorated concrete should be smoothed and/or repaired using either Mainstay ML-72 Sprayable Microsilica Mortar or Madewell 1312P Thixotropic Epoxy Putty. Refer to the applicable descriptive brochure for surface preparation and application instructions.

Steel: Apply only to clean, sound surfaces. All metal surfaces should be degreased or otherwise decontaminated prior to abrasive blast cleaning. Surfaces should be abrasive blast cleaned to a near white (NACE No. 2 or SSPC SP10) condition with a 2 to 4 mil anchor pattern depth.

MAINSTAY DS-4 may be used to topcoat steel surfaces which have been previously painted. However, compatibility with existing coatings (and adhesion of existing coatings) should be checked by application of a test patch.

PRIMING:
Not required for steel surfaces. Concrete surfaces should be primed with MADEWELL 927 Penetrating Epoxy Primer/Sealer. See descriptive brochure for surface preparation and application instructions. Apply MAINSTAY DS-4 to primed surfaces when the MADEWELL 927 Primer has cured dry to the touch (but as soon as possible thereafter to avoid contamination of the primed surfaces).

MIXING RATIO:
Mix components at a weight ratio of 20.2 parts A to 45.9 parts B. Whenever possible, avoid mixing partial kits.

MIXING:
This is a two component system. All components (liquids A and B) should be between 70° F and 90° F prior to mixing. The entire contents of each component should be thoroughly mixed individually before combining separate components together. Pour premeasured quantities of both components into a clean container and blend thoroughly using a power agi-

tator, such a Jiffy® mixer and a high strength industrial drill, for 5 minutes. Do not mix more material than can be used within stated working times.

WORKING TIME:

Approximately 45 minutes at 90° F. The working time will be extended somewhat at lower temperatures and shortened at higher temperatures.

THINNING:

Thinning is not recommended. Use MADEWELL 457 Thinner for cleanup of application equipment (see descriptive brochure).

APPLICATION:

This product is to be applied by trained workmen using specialized equipment. Both components must be preheated to 100⁰ F prior to application. A 56:1 airless spray pump at an air input pressure of ~90 PSI, is used to feed material through up to 50' of 1/2" diameter hose to a to a standard airless spray gun with a .031" to .035" reversible tip. It is recommended that 60 mesh in line strainers/filters be used. Other equipment, such as whip hoses, heaters or plural component equipment may be employed. MAINSTAY DS-4 can also be applied by brush, roller or airless spray. Contact a Madewell technical representative for specific equipment recommendations and sources.

MADEWELL DS-4 can be applied to MAINSTAY ML-72 within one to two hours after placing and finishing of the ML-72 mortar (when the ML-72 has just become firm to the touch). The unique, essentially simultaneous, application of these two produces is the basis for the *Mainstay Restoration and Corrosion Barrier System.* The application of these two products by this technique should only be performed by trained workmen who are employed by a contractor that has been licensed by Madewell Products Corporation to perform this type of work. Contact a Madewell representative for additional information regarding specific application instructions, applicator training and contractor licensing.

CURE TIME:

Foot traffic: 24 hours at 70° F.

Chemical service: 24 hours to 3 days, depending on the chemical service and temperature.

CLEAN UP:

MADEWELL 457 Thinner is recommended for equipment cleanup (see descriptive brochure). Skin should be cleaned using warm soapy water or commercial hand cleaner.

STORAGE:

Store components in sealed containers in dry environment at moderate temperature conditions (40° F to 80° F).

SHELF LIFE:

1 year, subject to reinspection thereafter.

SAFETY:

MAINSTAY DS-4 contains epoxy resins that *MAY CAUSE EYE OR SKIN SENSITIZATION.* Adequate health and safety precautions should be observed during all storage, handling, use and drying periods. For best results and safest usage, user is specifically directed to consult the current "Material Safety Data Sheet" for this product. When using this product in a confined space or closed area, consult the current OSHA or ANSI bulletins on safety requirements. Do not take internally. If swallowed, call a physician immediately. Keep away from open flame and keep containers tightly closed when not in use.

WARRANTY

All technical data, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowledge, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by the Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate or intended to suggest infringement of any existing patent. MADE-WELL PRODUCTS CORPORATION MAKES NO GUARANTEE OR WARRANTIES EXCEPT AS OTHERWISE PROVIDED IN WRITING, AND DISCLAIMS ANY AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

® Jiffy is a registered trademark of the Jiffy Mixer Company.

DS5084F

Madewell® 1312P

Thixotropic Epoxy Surfacer and Void Filler

Madewell®
"THE NAME SAYS IT ALL"

FEATURES/BENEFITS

SMOOTHS IRREGULAR SURFACES | MOISTURE TOLERANT
LOW SHRINKAGE | APPLIES BY TROWEL OR SQUEEGEE
EXCELLENT ADHESION | FAST SETTING

PRODUCT DESCRIPTION

MADEWELL® 1312P is a 100% solids thixotropic epoxy putty for use in filling irregular surfaces such as voids and bugholes in concrete prior to the application of protective or reinforcing topcoats. This two component product can be applied by trowel or squeegee. The absence of solvents reduces shrinkage, cracking and disbonding and eliminates problems related to solvent entrapment.

PRODUCT DATA

COMPOSITION:
100% Solids, modified epoxy putty

AVAILABLE COLORS:
Medium Gray

THICKNESS:
Depends on surface roughness. Although this product can be used to form a protective film, its primary purpose is to fill voids and pits in steel and concrete. When applied by trowel, it is normal to "strike off" all excess material so that the only product remaining is that which remains in voids, pits, "bugholes", etc.

COVERAGE:
Theoretical coverage is 1,604 mil square feet per gallon. Actual coverage depends on the condition of the surface being covered. Allowances should be made for waste.

PACKAGING:
Normally stocked in 43 lb. two component kits (approximately 3.5 gallons per kit). Larger and smaller kit sizes available on special order.

SURFACE PREPARATION:
Steel: Apply only to clean, sound surfaces. All metal surfaces should be degreased or otherwise decontaminated prior to abrasive blast cleaning. Surfaces should be abrasive blast cleaned to a near white (NACE No. 2 or SSPC SP10) condition with a 2 to 4 mil anchor pattern depth.

Concrete and Other Cementitious Surfaces: Concrete surfaces to be coated shall be free of laitance, grease, oil, and all other foreign materials. If required, the surfaces may be cleaned by sandblasting or other suitable mechanical means. Etching with muriatic acid may also be used to clean the surface, provided, however, that it is thoroughly broomed and flushed with a spray of fresh water to remove all salts. Surfaces should be free of standing or flowing water when MADEWELL 1312P is applied. If surfaces are extremely porous, weak or deteriorated, MADEWELL 927 Primer should be used to penetrate, seal and strengthen the surface prior to coating. See descriptive brochure.

Rough or deteriorated concrete should be smoothed and/or repaired using either Mainstay ML-72 Sprayable Microsilica Mortar or Madewell 1312P Thixotropic Epoxy Putty. Refer to the applicable descriptive brochure for surface preparation and application instructions.

MIXING RATIO:
Mix components at a weight ratio of 4.5 parts A to 1 part B. This is a multicomponent system. All components (liquids A and B) should be between 70° F and 90° F prior to mixing. The entire contents of both containers should be thoroughly mixed individually and then blended together by hand or with a power agitator for 5 minutes. Do not mix more material than can be used within stated working times.

POT LIFE:
Approximately 45 minutes at 100° F. Pot life will be extended at lower temperatures and shortened when higher.

THINNING:
Thinning is not recommended for topcoats. Use MADEWELL 457 THINNER for equipment cleanup (see descriptive brochure).

PRIMING:
Consult a Madewell technical representative for procedures particular to your application. Concrete surfaces may be primed with MADEWELL 927 PENETRATING EPOXY PRIMER-SEALER - see descriptive brochure for application and surface preparation details.

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Application:

Application can be performed by trowel, squeegee, or glove (consult a Madewell technical representative for specific equipment recommendations and sources). Concrete surfaces should be coated while they are cooling down to avoid blisters caused by expanding gas within pores and/or air pockets within the concrete. It can sometimes be difficult to effectively fill voids in concrete due to entrapped air which tends to push the Madewell 1312P back out. Blasting the concrete to completely open all voids and bugholes helps avoid this problem, however, several passes may be necessary to completely seal off all holes. Coating should be troweled, or otherwise applied, as smoothly as possible to avoid problems with topcoating after cure. When topcoating reinforced epoxy coatings such as Madewell 1312E, the glass reinforcement may be placed in the Madewell 1312P while in its uncured state.

Cure Time:

Madewell 1312P will cure to handle overnight at 75° F.

Clean Up:

MADEWELL 457 THINNER is recommended to clean equipment (see descriptive brochure). Skin should be cleaned using warm soapy water or commercial hand cleaner.

Storage:

Store components in sealed containers in dry environment at moderate temperature conditions (< 80° F).

Shelf Life:

1 year, subject to reinspection thereafter.

Safety:

MADEWELL 1312P contains epoxy resins that *MAY CAUSE EYE OR SKIN SENSITIZATION.* Adequate health and safety precautions should be observed during all storage, handling, use and drying periods. For best results and safest usage, user is specifically directed to consult the current "Material Safety Data Sheet" for this product. When using this product in a confined space or closed area, consult the current OSHA or ANSI bulletins on safety requirements. Do not take internally. If swallowed, call a physician immediately. Keep away from open flame and keep containers tightly closed when not in use.

Warranty

All technical data, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowledge, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by the Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate or intended to suggest infringement of any existing patent. MADEWELL PRODUCTS CORPORATION MAKES NO GUARANTEE OR WARRANTIES EXCEPT AS OTHERWISE PROVIDED IN WRITING, AND DISCLAIMS ANY AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

DS5084G

Madewell® 1312S

Epoxy Coating System

Madewell®
"THE NAME SAYS IT ALL"

FEATURES/BENEFITS

HEAVY DUTY RESISTANCE TO:
CHEMICAL ATTACK
ABRASION
IMPACT DAMAGE

EASY APPLICATION & CLEANUP
FAST SETTING
EXCELLENT EXTERIOR DURABILITY
NON TOXIC - EASY TO CLEAN SURFACE

PRODUCT DESCRIPTION

MADEWELL® 1312S is a heavy duty, 100% solids two component epoxy coating product. It is used for both new construction and maintenance of steel and concrete surfaces in tanks, sumps, trenches, decks and pipe interiors and other process equipment and structures in chemical processing, power, refining, mining, pulp and paper and oil refining industries. MADEWELL 1312S may be used as a topcoat for other MADEWELL 1312 series coating systems to add color and/or seal the surface.

MADEWELL 1312S protects surfaces against chemical attack under immersion, spill, and splash conditions and impact and abrasion damage by rough use or heavy traffic. It is normally applied at a nominal thickness of 10 to 25 mils in two coats. Being attractive and easy to clean, its monolithic construction resists moisture, chemical and bacteria penetration. Its free spreading characteristics, fast set time and easy cleanup help to minimize labor costs and down time.

PRODUCT DATA

COMPOSITION:

100% Solids, two component epoxy

FINISH:

Semigloss

AVAILABLE COLORS:

Standard: White, light grey, or light blue. Custom colors available upon request.

THICKNESS:

10 to 25 mils in two coats. Consult a Madewell technical representative for specific recommendations.

COVERAGE:

Approximately 75 ft² per gallon at 20 mils. Allowances should be made for waste.

PACKAGING:

Normally stocked in 4.5 gallon two component kits. Larger and smaller kits are available on special order.

SURFACE PREPARATION:

Concrete: Concrete surfaces should be primed with MADEWELL 927 Penetrating Epoxy Primer/Sealer. See descriptive brochure for surface preparation and application instructions. Apply MADEWELL 1312S to primed surfaces when the MADEWELL 927 Primer has cured dry to the touch (but as soon as possible thereafter to avoid contamination of the primed surfaces).

Rough or deteriorated concrete should be smoothed and/or repaired using either Mainstay ML-72 Sprayable Microsilica Mortar or Madewell 1312P Thixotropic Epoxy Putty. Refer to the applicable descriptive brochure for surface preparation and application instructions.

Steel: Apply only to clean, sound surfaces. All metal surfaces should be degreased or otherwise decontaminated prior to abrasive blast cleaning. Surfaces should be abrasive blast cleaned to a near white (NACE No. 2 or SSPC SP10) condition with a 2 to 4 mil anchor pattern depth.

MADEWELL 1312S may be used to topcoat steel surfaces which have been previously painted. However, compatibility with existing coatings (and adhesion of existing coatings) should be checked by application of a test patch.

PRIMING:

Not required for steel surfaces. Concrete surfaces should be primed with MADEWELL 927 Penetrating Epoxy Primer/Sealer. See descriptive brochure for surface preparation and application instructions. Apply MADEWELL 1312S to primed surfaces when the MADEWELL 927 Primer has cured dry to the touch (but as soon as possible thereafter to avoid contamination of the primed surfaces).

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Mixing Ratio:
Mix components at a weight ratio of 2 parts A to 1 part B.

Mixing:
This is a two component system. All components (liquids A and B) should be between 70° F and 90° F prior to mixing. The entire contents of each component should be thoroughly mixed individually before combining separate components together. Pour premeasured quantities of both components into a clean container and blend thoroughly using a power agitator, such a Jiffy® mixer and a high strength industrial drill, for 5 minutes. Do not mix more material than can be used within stated working times.

Working Time:
Approximately 45 minutes at 70° F. The working time will be extended somewhat at lower temperatures and shortened at higher temperatures.

Thinning:
Thinning is not recommended. Use MADEWELL 457 THINNER for clean-up of application equipment (see descriptive brochure).

Application:
MADEWELL 1312S can be applied by brush, roller, conventional or airless spray. Contact a Madewell technical representative for specific equipment recommendations and sources.

Cure Time:
Foot traffic: 24 hours at 70° F.

Chemical service: 24 hours to 7 days, depending on the chemical service and temperature.

Clean Up:
MADEWELL 457 THINNER is recommended for equipment cleanup (see descriptive brochure). Skin should be cleaned using warm soapy water or commercial hand cleaner.

Storage:
Store components in sealed containers in dry environment at moderate temperature conditions (40° F to 80° F).

Shelf Life:
1 year, subject to reinspection thereafter.

Safety:
MADEWELL 1312S contains epoxy resins that *MAY CAUSE EYE OR SKIN SENSITIZATION.* Adequate health and safety precautions should be observed during all storage, handling, use and drying periods. For best results and safest usage, user is specifically directed to consult the current "Material Safety Data Sheet" for this product. When using this product in a confined space or closed area, consult the current OSHA or ANSI bulletins on safety requirements. Do not take internally. If swallowed, call a physician immediately. Keep away from open flame and keep containers tightly closed when not in use.

Warranty
All technical data, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowledge, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by the Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate or intended to suggest infringement of any existing patent. MADEWELL PRODUCTS CORPORATION MAKES NO GUARANTEE OR WARRANTIES EXCEPT AS OTHERWISE PROVIDED IN WRITING, AND DISCLAIMS ANY AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

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Appendix 4: Replacement of Metallic Doors with Non-Corroding Composite Fiber-Reinforced Plastic Doors at Fort Bragg

Robert H. Heidersbach
June 2006

Executive summary

Military installations are like small cities in many ways, and the physical plant of military installations has many utility systems similar to those used on civilian installations.

This report discusses the replacement of corroded steel doors on a water treatment plant with corrosion-resistant fiber reinforced plastic (FRP) doors. These doors should last longer in the aggressive corrosive service characteristic of water treatment plants.

Fort Bragg, North Carolina, was chosen for this project. Steel doors on a water treatment plant at Fort Bragg were replaced in November 2005 with FRP doors.

Similar doors were installed somewhat earlier at Fort Drum, New York. Comparisons between these doorway applications are also included.

1 Introduction

Background

Military installations may have hundreds of buildings and thousands of doors. Door repair and replacement costs millions of dollars annually at large military installations. One of the problems associated with doors is corrosion, especially of exterior doors. Army posts have limited guidelines on how to choose doors and what materials can be expected to last longer than others. Improved door materials have been developed in recent years

that may offer reductions in maintenance repair costs if they prove to be more resistant to degradation than older traditional doors.

Fort Bragg, North Carolina, was chosen for this study because it is one of the largest Army installations, with door replacement costs running into the millions of dollars annually. The domestic water treatment plant at Fort Bragg was identified for door replacement, and the conditions of the original steel doors and the replacement fiber glass reinforced plastic (FRP) doors is documented in this report. Most of the replaced doors were similar to those that would be used in barracks, administrative buildings, and similar locations, but the special demands of an industrial location are also presented.

Objectives

The objectives of this project were to demonstrate the installation of fiber-reinforced (FRP) doors, compare them with steel door performance, and determine if any improvements in performance, or limitations on improved performance, could be identified.

Approach

R. Heidersbach, Dr. Rust, Inc., conducted two inspections of the doors in question at Fort Bragg. The first inspection was in September 2004, and the final inspection was in December 2005, after the doors were replaced. On a separate project, Dr. Heidersbach also inspected FRP doors at Fort Drum, New York. The information on these Fort Drum doors was supplied to Fort Bragg personnel who chose to use the same door supplier for their FRP doors. A brief discussion of problems with the Fort Drum doors after approximately two years of use is included in this report.

2 Condition before replacement

The exterior doors of the water treatment plant at Fort Bragg are shown in Figures 1-4. These photos were taken by R. Heidersbach, Dr. Rust, Inc., during a preliminary inspection of facilities at Fort Bragg in September 2004.

Figure 1. Corroded metallic doorway at the Fort Bragg water treatment plant.

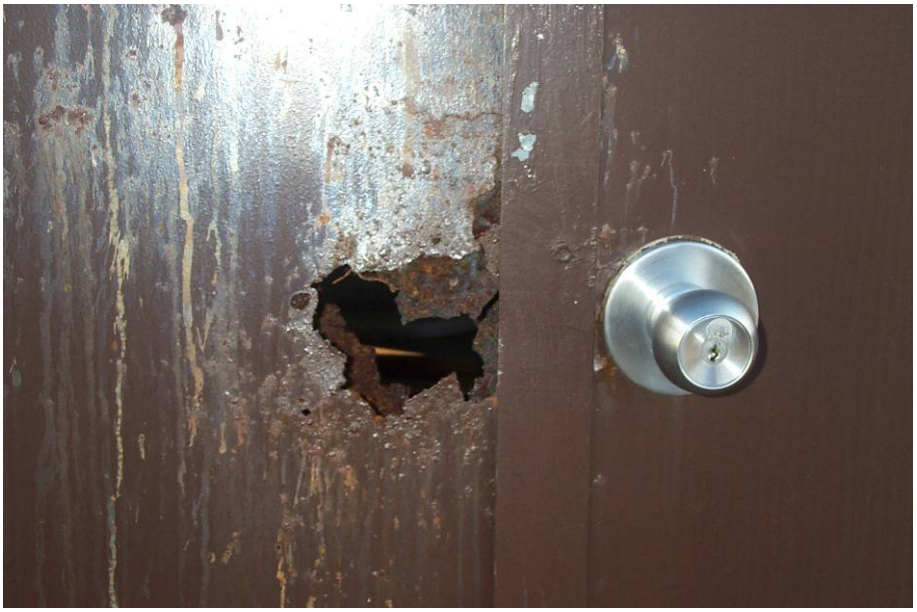


Figure 2. Closeup of corrosion on doors shown in Figure 1.

Figure 3. Corrosion of the bottom of the doors shown in Figure 2.

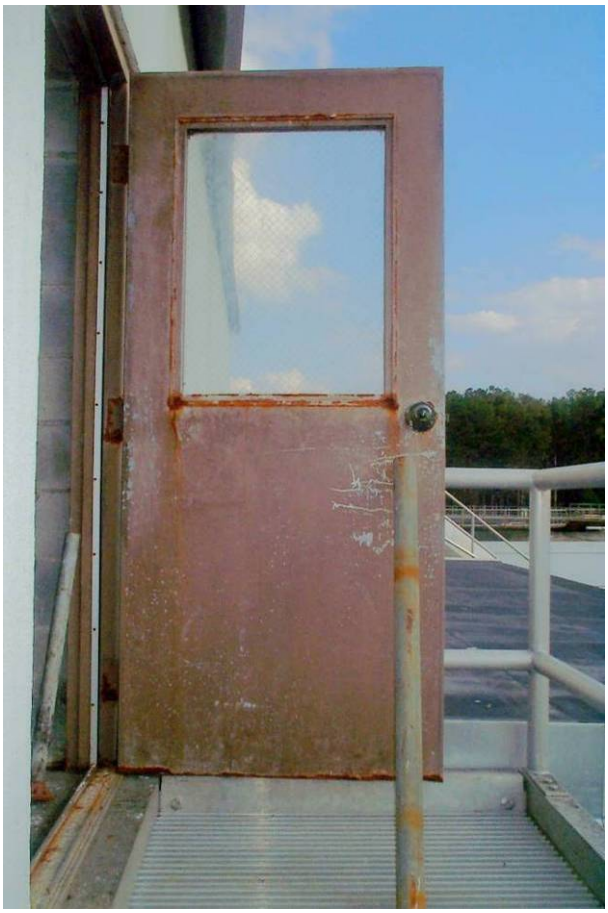


Figure 4. Corroded metallic doorway at the Fort Bragg water treatment plant.

The doors shown in Figures 1–4, and other doors on the same building, were scheduled for replacement with FRP doors, which should be more resistant to corrosion and weather. The lack of sills or other overhangs contributes to the corrosion of these doors, but they have also deteriorated due to the aggressive nature of the chemicals in use at the water treatment plant.

3 Installation of replacement doors

A number of suppliers of fiber reinforced plastic (FRP) doors for exterior use are available. These suppliers advertise on the Internet, in Sweet's catalogs, Thomas Register, and other listings of industrial and construction equipment.

The doors of the water treatment plant were replaced by a contractor in November 2005. Figure 5 shows the new doors that replaced the doors shown in Figures 1 through 3.

Figure 5. Replacement doors for the doors shown in Figures 1–3 above.

The concrete block surrounding the doorway had also deteriorated and needed to be replaced. The repaired wall and new door sills allowed replacement with standard-sized doors in this location.

The loading doors at the opposite end of the building are shown in Figures 6 and 7.

Figure 6. Doors on the opposite end of the building from those shown in Figure 5.

Figure 7. Interior view looking out at door shown in Figure 6. Arrows point to stainless steel hardware necessary because of corrosive conditions at this location. Note the chemical gas cylinders in the foreground.

The chemicals stored inside the building at this location are contained in large steel cylinders that are moved using an overhead winch and pulley

system. The carbon steel overhead rail for this system was not replaced, although it was repainted at the time the new doors were installed.

Figures 8 and 9 show the overhead FRP door sill that was cut to accommodate the steel rail. Stainless steel screws were used to attach the FRP sill to the masonry building.

Figure 8. Overhead track used for moving cylinders into the room shown in Figure 6.

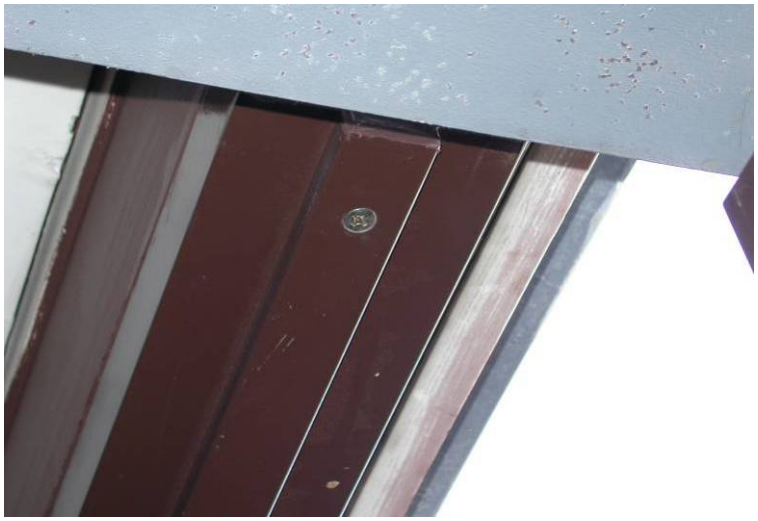


Figure 9. Overhead door sill cut to allow equipment loading track shown in Figure 8.

Deterioration of the door jamb necessitated new FRP door jambs that were installed around the doorway. Figures 10 and 11 show details on the left

side of the doorway shown in Figure 7. Because of the corrosive conditions in this location, it was necessary to utilized stainless steel screws, hinges, and other hardware for this entire installation.

Figure 10. Special door jamb fabricated for the FRP doors shown in Figs. 5–7.

Figure 11. Stainless steel hinges for doors shown in Figs. 6–10.

Some of the chemicals shown in the room discussed in Figures 6–11 are mixed and used in the room behind the door shown in Figure 12. The corrosive acids used in water treatment have etched the concrete floor of this room. The floor etching due to chemical spills is apparent in Figure 13.

Figure 12. Pedestrian door leading to chemical room at water treatment plant at Fort Bragg.

Figure 13. Interior of room behind door shown in Figure 7. Note the etching of the concrete floor due to spills of acid onto the floor.

Acid fumes have also caused corrosion of the wall mounted air conditioner in this room, as shown in Figure 14.

Figure 14. Wall mounted air conditioner on the wall above the equipment shown in Figure 13.

Acids are corrosive to carbon steel and concrete. They are also corrosive to zinc and aluminum, two coating metals frequently specified for retarding corrosion in atmospheric environments. This is emphasized in Figure 15, which shows the relative corrosion rates of aluminum and iron (carbon steel) at varying pH's.

Acids have low pH and bases have high pH. Neutral environments around pH 7 are less corrosive to aluminum and zinc, and, therefore, can be used as protective coatings in many atmospheric environments, but not in acidic atmospheres. The concrete shown on the floor in Figure 13 is a base. That is why it has reacted so strongly with the acid spills onto the floor. Fortunately, the floor is relatively thick and the surface roughening has caused no major problems in this location.

Stainless steels are the preferred hardware material for doors used in corrosive environments because they are resistant to most acids and bases likely to be encountered by doors and similar construction components.

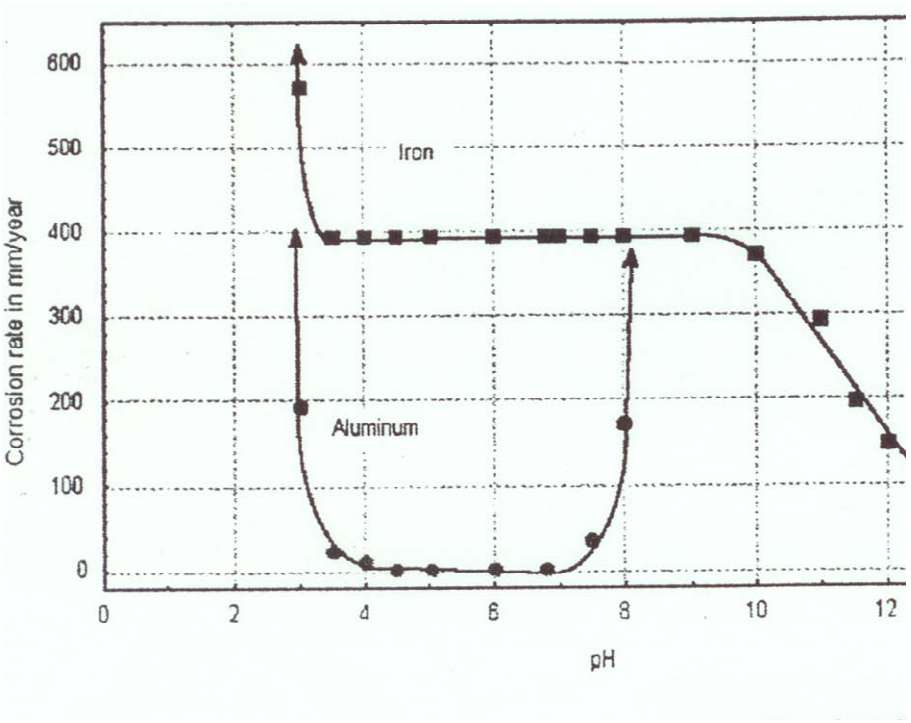


Figure 15. Effect of varying pH of the environment on the corrosion of iron and aluminum.

4 Special considerations

Ultraviolet degradation and mechanical strength are two limitations to be considered when specifying FRP doors and hardware. FRP can also burn, but modern FRP doors can be purchased with fire ratings suitable for many applications, to include the doors shown in this report.

All plastics are subject to ultraviolet (UV) degradation. This can be handled by specifying that the materials must be supplied with UV resistant additives. These additives absorb the sunlight (visible and UV) and prevent damage from proceeding further into the material. If this is done, no major damage due to UV degradation should occur over a period of many years. Suppliers of doors, windows, and related hardware are familiar with this problem and provide materials treated to minimize UV damage.

The other limitation of FRP doors is that, while they are relatively stiff (strong) for their weight, point loading at fasteners can cause loss of contact at places where the FRP is subject to high loads.

During a parallel project at Fort Drum, New York, several FRP doors that were approximately two years old were examined. Figures 16 and 17 show one of these doors. The panic bar on the door is pulling away from the door, as shown in Figure 17. The solution to this problem is to attach a stainless steel backer plate to the outside of the door and bolt the metal on both sides together.

Figure 16. A two-year old FRP pedestrian door at Fort Drum, New York

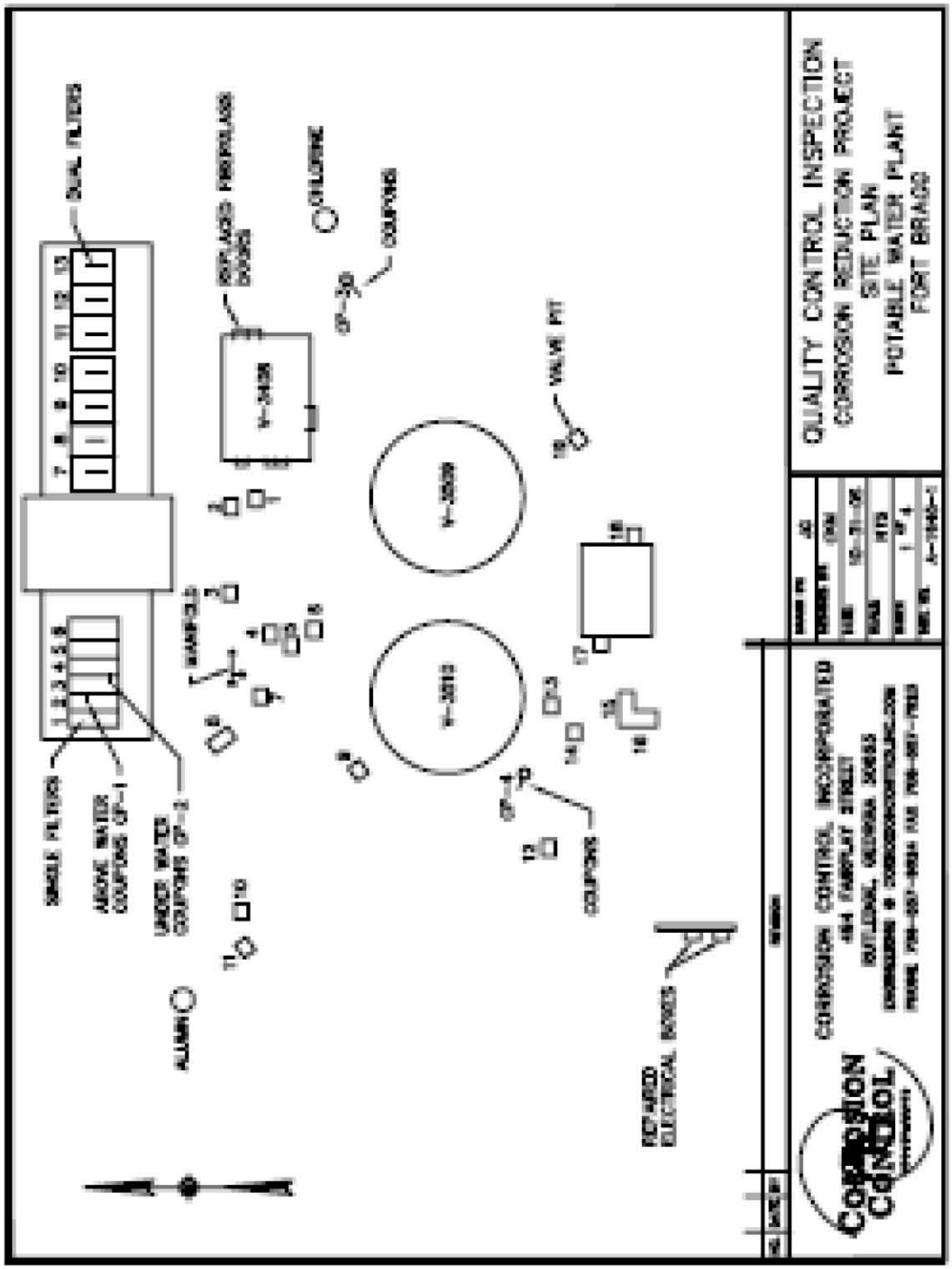
Figure 17. Screws attaching the panic bar to the door shown in Figure 16 showing that the door has bent and pulled the screws from the door.

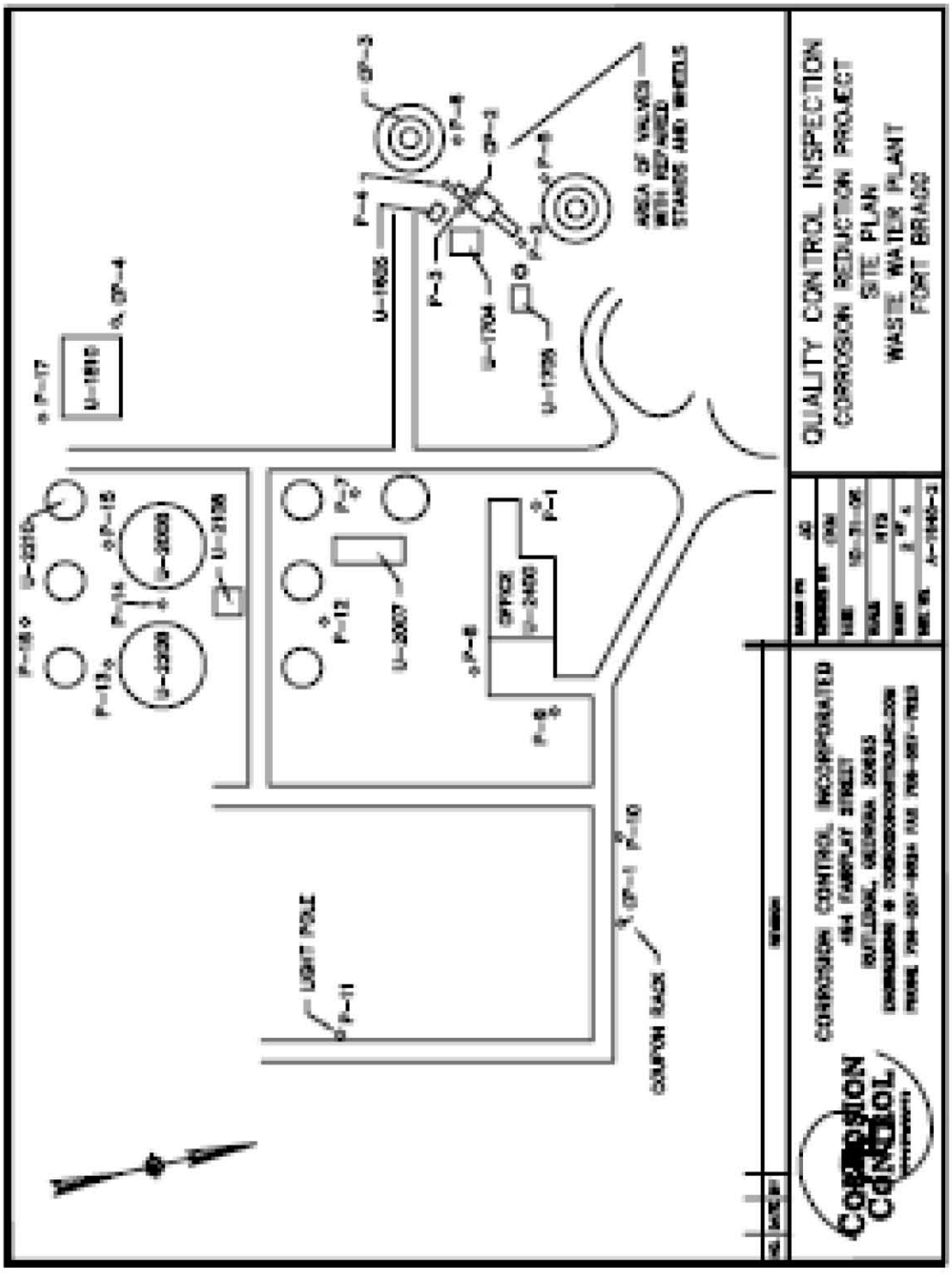
The problem shown in Figure 17 is not a corrosion problem, but it does indicate a problem associated with the use of composite doors. They can be more flexible than the steel doors they replace, and stripping screws from the hardware is more likely on composite doors than with solid wooden doors or with most steel doors.

5 Summary and conclusions

FRP doors have been installed at Fort Bragg and Fort Drum. The doors at Fort Bragg are too new to have developed any problems, but they should perform better than the steel doors they replaced. Inspecting these doors on a 5-year basis to see if they perform as well as predicted is recommended.

Appendix 5: Locations of Corrosion Rate Coupons at Fort Bragg WTP and WWTP


QUALITY CONTROL INSPECTION
CORROSION REDUCTION PROJECT
SITE PLAN
POTABLE WATER PLANT
FORT BRAGG
DUAL FILTERS
SINGLE FILTER
ABOVE WATER COUPONS CP-1
BURIED WATER COUPONS CP-2
ALARM
REPLACED FIBERGLASS BOOSTER
CHLORINE
CP-30
COUPONS
VALVE PIT
COUPONS
REPLACED ELECTRICAL BOXES


QUALITY CONTROL INSPECTION
CORROSION REDUCTION PROJECT
SITE PLAN
WASTE WATER PLANT
FORT BRAGG
CORROSION CONTROL INCORPORATED
484 FAIRPLAY STREET
BUILDING, GEORGIA 30053
CORROSION CONTROL
LIGHT POLE
COMPTON ROAD

Appendix 6: Return-On-Investment (ROI) Calculations and Supporting Assumptions

The original ROI assumptions and calculations as presented in the PMP dated 12 July 2004 were validated for this project:

Alternative 1: A 2002 study on the Fort Bragg Water and Wastewater Treatment Plants, titled "*U. S. Army Corps of Engineers Government 'Should-Cost' Model for Privatization of Water-Wastewater Utility System*", identified the following costs:

Annual Capital Improvement Costs= $3.0M
Annual Water & Wastewater Plant O&M= $5.2M
Total Cost for both Plants= $8.2M

The total cost is $8.2 M, and is used as the Annual Baseline costs for both plants, and is shown under *Baseline Costs* in the ROI spreadsheet.

Alternative 2: Implementation of the Corrosion-resistant Materials at the Water Treatment Plant and Wastewater Treatment Plant at a cost of $1.06M can be expected to reduce both the required annual capital improvement costs and the annual O&M costs by 15%. These costs are shown under *New System Costs* in the ROI Spreadsheet. Comparing the two alternatives, the potential return-on-investment for alternative 2 is projected to be 14.40

Return on Investment Calculation

Materials ROI

Investment Required			**1,060,000**
Return on Investment Ratio	**14.40**	**Percent**	**1440%**
Net Present Value of Costs and Benefits/Savings	**86,488,639**	**101,751,340**	**15,262,701**

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	8,200,000		6,970,000		6,514,162	7,663,720	1,149,558
2	8,200,000		6,970,000		6,087,598	7,161,880	1,074,282
3	8,200,000		6,970,000		5,689,611	6,693,660	1,004,049
4	8,200,000		6,970,000		5,317,413	6,255,780	938,367
5	8,200,000		6,970,000		4,969,610	5,846,600	876,990
6	8,200,000		6,970,000		4,644,111	5,463,660	819,549
7	8,200,000		6,970,000		4,340,219	5,106,140	765,921
8	8,200,000		6,970,000		4,056,540	4,772,400	715,860
9	8,200,000		6,970,000		3,790,983	4,459,980	668,997
10	8,200,000		6,970,000		3,542,851	4,168,060	625,209
11	8,200,000		6,970,000		3,311,447	3,895,820	584,373
12	8,200,000		6,970,000		3,094,680	3,640,800	546,120
13	8,200,000		6,970,000		2,892,550	3,403,000	510,450
14	8,200,000		6,970,000		2,702,966	3,179,960	476,994
15	8,200,000		6,970,000		2,525,928	2,971,680	445,752
16	8,200,000		6,970,000		2,360,739	2,777,340	416,601
17	8,200,000		6,970,000		2,206,702	2,596,120	389,418
18	8,200,000		6,970,000		2,062,423	2,426,380	363,957
19	8,200,000		6,970,000		1,927,205	2,267,300	340,095
20	8,200,000		6,970,000		1,801,048	2,118,880	317,832
21	8,200,000		6,970,000		1,683,255	1,980,300	297,045
22	8,200,000		6,970,000		1,573,129	1,850,740	277,611
23	8,200,000		6,970,000		1,469,973	1,729,380	259,407
24	8,200,000		6,970,000		1,373,787	1,616,220	242,433
25	8,200,000		6,970,000		1,283,874	1,510,440	226,566
26	8,200,000		6,970,000		1,200,234	1,412,040	211,806
27	8,200,000		6,970,000		1,121,473	1,319,380	197,907
28	8,200,000		6,970,000		1,048,288	1,233,280	184,992
29	8,200,000		6,970,000		979,982	1,152,920	172,938
30	8,200,000		6,970,000		915,858	1,077,480	161,622

AR-F-319: CORROSION RESISTANT MATERIALS FOR FRESHWATER AND WASTEWATER TREATMENT PLANTS AT FT. BRAGG, NC

INDEPENDENT ECONOMIC SUMMARY AND RETURN ON INVESTMENT (ROI) CALCULATION

LEO C. MUELLER
ALLIED CORROSION INDUSTRIES, INC.
PO BOX 9098
MARIETTA, GA 30065-2098

The following summary table represents the investment costs, the replacement cost, and the life expectancy of each structure by implementing the corrosion control processes (task) covered by this contract:

TABLE 1. Freshwater Treatment Plant

Task No.	Qty.	Description	Refurbishment Cost/each	Replacement Cost/each	Life Expectancy*
1	6	Refurbish the concrete in single filters	8154.00	60,000	15
2	4	Refurbish the concrete in dual filters (2 cells/filter)	22,041.25	120,000	15
3	6	Refurbish the coating in the single filters on the metal troughs and wash piping	3592.33	10,000	15
4	7	Coat the new wash piping in the dual filters	1216.00	8000	15
5	19	Refurbish the coating on the piping and valves in below ground pits	2143.00	20,000	15
6	1	Refurbish the coating on large, above ground piping manifold	2410.80	40,000	15
7	2	Refurbish the coating on electrical panel box	983.50	2250	15

TABLE 2. Wastewater Treatment Plant					
1	17	Refurbish the coating on 40' tall yard light poles	2277.60	4000	15
2	19	Refurbish the coating on remote valve hand wheels	212.85	375	15
3	11	Refurbish the coating on valve operator support stands	162.00	2000	15
4	10	Refurbish and seal stainless steel electrical motor control/circuit breaker panel boxes	3000.00	5000	15
5	3	Replace one single and two double metal doors with FRP doors	17,500.00	5000	30
6	3	Replace badly corroded valve hand wheels	212.85	375.00	15

* Life Expectancy is defined as the extended amount of life the structure should have by the implementation of the recommended refurbishment process shown in the Submittal Task Description Manual.

ACI's approach to the "Return on Investment" (ROI) calculations is a very conservative approach. Actual cost avoidance issues that the US Government will benefit from were not included in the ROI calculations as they were subject to an individual's personal opinion and his predictions of what the future may or may not hold. Because of this purely subjective view, ACI did not speculate in this area of the calculations.

ROI Calculation Assumptions:

Alternative 1: A 2002 study on the Ft. Bragg Water and Wastewater Treatment Plants, titled "U. S. Army Corp of Engineers Government 'Should-Cost' Model for Privatization of Water-Wastewater Utility System", identified the following costs:

Annual Capital Improvements costs = $3.0M

Annual Water & Wastewater Plant O&M = $5.2M

Total Cost for both Plants = $8.2M

The total cost is $8.2M, and is used as the Annual Baseline Costs for both plants, and is shown under *Baseline Costs* in the ROI spreadsheet.

Replacement costs of the components in Table 1 and Table 2 are included under baseline costs in the years in which they would have to be replaced.

Alternative 2: Implementation of the corrosion resistant Materials at the Water Treatment Plant and the wastewater Treatment Plant at a cost of 1.06M can be expected to reduce both the required annual capital improvement costs and the annual O&M costs by 15%. These costs are shown under *New System Costs* in the ROI spreadsheet.

It is assumed that all component have lives of 15 years and would have to be replaced in Year 15 and Year 30.

Comparing the two alternatives, the potential return-on-investment for Alternative 2 is projected to be **14.6%**.

Return on Investment Calculation

Investment Required			**1,060,000**
Return on Investment Ratio	**14.58**	**Percent**	**1458%**
Net Present Value of Costs and Benefits/Savings	**86,524,183**	**101,976,166**	**15,451,983**

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	8,205,375		6,970,000		6,514,162	7,668,743	1,154,581
2	8,200,000		6,970,000		6,087,598	7,161,880	1,074,282
3	8,406,200		6,970,000		5,689,611	6,861,981	1,172,370
4	8,200,000		6,970,000		5,317,413	6,255,780	938,367
5	8,205,375		6,970,000		4,969,610	5,850,432	880,822
6	8,205,000		6,970,000		4,644,111	5,466,992	822,881
7	8,200,000		6,970,000		4,340,219	5,106,140	765,921
8	8,200,000		6,970,000		4,056,540	4,772,400	715,860
9	8,200,000		6,970,000		3,790,983	4,459,980	668,997
10	8,268,175		6,970,000		3,542,851	4,202,713	659,862
11	8,205,000		6,970,000		3,311,447	3,898,196	586,749
12	8,200,000		6,970,000		3,094,680	3,640,800	546,120
13	8,200,000		6,970,000		2,892,550	3,403,000	510,450
14	8,200,000		6,970,000		2,702,966	3,179,960	476,994
15	8,200,375		7,041,980		2,552,014	2,971,816	419,802
16	8,205,000		6,970,000		2,360,739	2,779,034	418,295
17	8,200,000		6,970,000		2,206,702	2,596,120	389,418
18	8,200,000		6,970,000		2,062,423	2,426,380	363,957
19	8,200,000		6,970,000		1,927,205	2,267,300	340,095
20	8,207,675		6,970,000		1,801,048	2,120,863	319,815
21	8,205,000		6,970,000		1,683,255	1,981,508	298,253
22	8,200,000		6,970,000		1,573,129	1,850,740	277,611
23	8,200,000		6,970,000		1,469,973	1,729,380	259,407
24	8,200,000		6,970,000		1,373,787	1,616,220	242,433
25	8,207,375		6,970,000		1,283,874	1,511,798	227,924
26	8,205,000		6,970,000		1,200,234	1,412,901	212,667
27	8,200,000		6,970,000		1,121,473	1,319,380	197,907
28	8,200,000		6,970,000		1,048,288	1,233,280	184,992
29	8,200,000		6,970,000		979,982	1,152,920	172,938
30	8,200,375		7,041,980		925,316	1,077,529	152,213

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14. ABSTRACT

Corrosion prevention and control technologies using advanced materials and coatings were implemented at the water treatment and wastewater treatment facilities at Fort Bragg, NC. This project demonstrated that: (1) Microsilica cement mortar and epoxy based coatings, approved for potable water according to National Sanitation Foundation (NSF) Standard 61, were applied to the potable water treatment filter tanks. These coatings form a high strength moisture barrier with a strong chemical/mechanical bond to brick and cementitious substrates. (2) Coal-tar epoxy coatings are efficacious in the presence of moderate concentrations of airborne chlorine and hydrogen sulfide gases and were used in wastewater treatment facilities. (3) Fiber-reinforced plastic doors, which provide excellent mechanical durability and superior resistance to sunlight and corrosion, especially in chlorine storage facilities, were installed.

These technologies are applicable to other potable water treatment plants and wastewater treatment plants for Army and DoD installations, and can be expected to result in restoration of the plants to optimum operating conditions and significant cost avoidance due to increased service life.

15. SUBJECT TERMS
Fort Bragg, NC; corrosion prevention; water treatment plant (WTP); wastewater treatment plant (WWTP); fiber-reinforced plastic (FRP)

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